Numerical Comparison of Heat Transfer Enhancement Between Helical Fin And Rectangular Fin In Double Pipe Heat Exchanger

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Abstract- *Now a days, heat transfer enhancement in heat exchangers is most important. Heat transfer enhancement is the process of improving the performance of a heat transfer system. It generally means increasing the heat transfer coefficient. The various heat transfer enhancement techniques are available such as finned surfaces integral roughness, insert devices and using nano fluids. In this paper, comparison of two heat transfer techniques are insertion of rectangular fins and helical fin in double pipe heat exchanger by using CFD analysis. Here, 8 rectangular fins and 20 mm pitch length in 750 mm length double pipe heat exchanger used and both fin thickness is 2 mm. The performance of heat exchanger of temperature distribution and pressure drops are analyzed, the best heat exchanger is displayed and the reasons are discussed.*

Keywords- Double pipe heat exchanger, Heat transfer enhancement, helical fin and rectangular fin and techniques comparison.

I. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are no external heat and work interactions. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single or multi component fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize ,fractionate, distill, concrete, crystallizer control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact.

Different heat transfer applications require different types of hardware and different configurations of heat transfer equipment. The attempt to match the heat transfer hardware to the heat transfer requirements within the specified constraints has resulted in numerous types of innovative heat exchanger designs. There are

- Double pipe heat exchanger
- Cross flow heat exchanger
- Shell and tube type heat exchanger

Heat exchangers are widely used in various industries such as thermal energy plants, refrigeration, heat pump and air conditioning system, low temperature engineering, chemical process engineering, and so on. If the performance and efficient of thermal systems in various industries can be vastly improved, the size of heat exchangers will be reduced and, thereby, a large amount of costs and spaces will be saved. The enhancements (or augmentations) of heat transfer has became an important factor is achieving these goals. One of the important challenges in the design of heat exchangers is the enhancement of single phase heat transfer, especially, when heat exchangers have single phase fluid flow on one side and a two phase flow or phase change on the other side. Common examples are condensers, evaporators, boilers and other such heat exchangers used and industrial applications.

The heat transfer rate may be increased by increasing the surface area across which the convection occurs. This may be done by employing fins that extend from the wall into the surrounding fluid. The thermal conductivity of the fin material can have a strong effect on the temperature distribution along the fin and therefore influences the degree to which the heat transfer rate is enhanced.

II. LITERATURE SURVEY

SWATHI JUTURU, J.KISHORE - For given dimensions of the double pipe heat exchanger with selected rectangular fins, copper twisted tape is inserted into the inner pipe of the double pipe heat exchanger as first setup of heat exchanger. . But second setup of heat exchanger is fabricated with copper twisted tape only without fins at the outside of the inner copper pipe in second heat exchanger. Comparing these two heat exchangers, effectiveness is more for first heat exchanger.

M. RAJESHKUMAR, K. LOGESH, M. THANGARAJ & S. GOVINDAN-, In this paper, the performance of Tube heat exchanger is studied with a different arrangement of Fins using CFD. This Analysis is done for an existing tube heat exchanger with the specified conditions of the inlet flow and the heat exchange between the three different nozzles is modeled through ANSYS, analysis of Heat Exchanger by Steady-State Thermal was successfully carried out. The program implemented in this design can be further modified to support each and every system

MR. DEEPAK SEN, PROF. DR. ALKA AGRAWAL- The main aim of this thesis is to compare and improve the various heat transfer parameters like overall heat transfer coefficient, heat transfer rate, effectiveness, NTU etc. in double pipe heat exchanger for four different cases i.e. Plain tube, Corrugated tube, Plain tube with helically twisted wire and Plain tube with twisted clip . The above work is done experimentally on concentric tube heat exchanger. This works falls under Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. The data obtained from experiment were used for calculating the various parameters as discussed.

SNEHA DHORIA, IMMADISETTY VENKATA SAI YESWANTH - The purpose of this project is to use ANSYS FLUENT 17.1 software and theoretical calculations to analyze the temperature drops as a function of both inlet velocity and inlet temperature and how each varies with the other. Each heat exchanger model was designed and simulated for both parallel flow and counter flow heat exchanger models.

BARU DEBTERA BEJENA, S.VENKATESA PRABHU, IBSA NEME,- The CFD software was implemented successfully to couple heat transfer model and standard turbulent model in double pipe heat exchanger. The temperatures inlet in tube and annulus were maintained at 415K and 300K, respectively for hot fluid in tube while cold fluids in annulus.

G. RAGOT AMAN, T. MOTHILAL, S.P. DHANUSH- In this design, we have created baffles on the inner surface of the inner pipe, to cause disturbance in the path of fluids which will create turbulence in the flow. These turbulences will resist the settling down of nano particles along the length of the pipe during long runs. The analysis is carried out for various concentrations of CuO in the base fluid (water). The flow and temperature distribution inside the tube is done and studied using Computational Fluid Dynamics(by ANSYS Fluent software).This work determines the enhancement in heat transfer rate, better performance of heat exchanger using CuO nano fluid and its overall heat transfer co-efficient.

P.C. MUKESH KUMAR, M. CHANDRASEKAR - The design of new shell and double helically coiled tube heat exchanger was done by using standard designing procedure and 3D modeling was done in Creo 2.0 parametric. The Finite Element Analysis software ANSYS Workbench 14.5 was used to perform CFD analysis under the standard working condition. The MWCNT/water nano fluids at 0.2%, 0.4%, and 0.6% volume concentrations have been taken for this investigation.

The above reaches explains the performance of heat exchanger is increased by using adding the strips, coils and nano fluids which are presented numerically or experimentally. So, I have idea from the journals a double pipe heat exchanger can be analyze the comparison of two techniques of heat transfer enhancement methods. The most commonly used the double pipe heat exchangers in industrial applications

III. METHODOLOGY

- This literature review section provides an insight into the research work already undertaken on the subject heat exchangers with helical turbulator.
- Virtual modeling of the heat exchanger with turbulator in 3-dimentions using 3D CAD software- SOLID WORKS
- Importing the 3D model into the ANSYS CFX environment for a finite element discretization and subsequent use in the CFX environment.
- Definition of the CFD analysis in terms of boundary conditions inlet and outlet and other parameters.
- Running the CFD flow simulation for different configurations for the heat exchanger and extraction of results visually and quantitatively.
- Detailed comparative analysis of all results and drawing inferences.
- Quantitative analysis and comparison to extract tangible results and to establish the relative merits and demerits of various cases and to arrive at definitive conclusions.

IV. MODELING AND SIMULATION

This is initial step in analysis process. The primary purpose of geometry creation is to generate a solid that defines region for fluid flow. Dimensions and geometry details of existing model was collected.

Modeling was done using solid edge 20 and exported in IGES format. The models of nozzles heads have been shown in figures. The part modeling was used to construct the heat exchanger. The following figures show the double pipe heat exchanger with helical and rectangular fins.

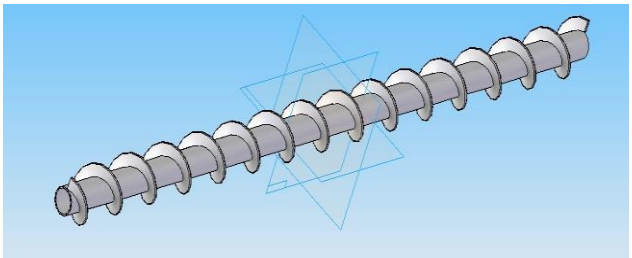

Fig 1: Double pipe heat exchanger with helical fins

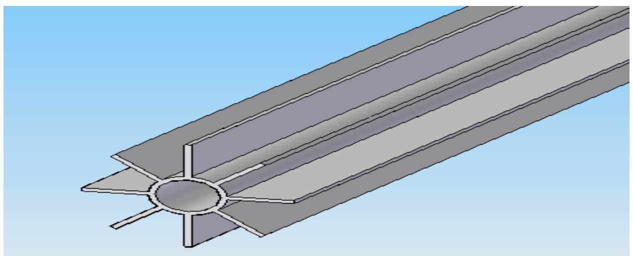

Fig 2: Double pipe heat exchanger with rectangular fins

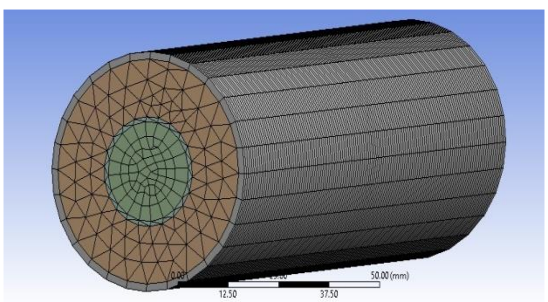

Fig 3: Meshing of helical fins heat exchanger

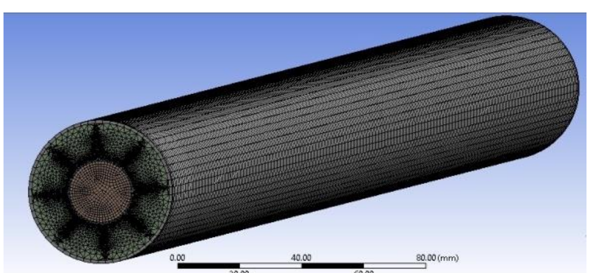

Fig4: Meshing of rectangular fins heat exchanger

A. TEMPERATURE DISTRIBUTION

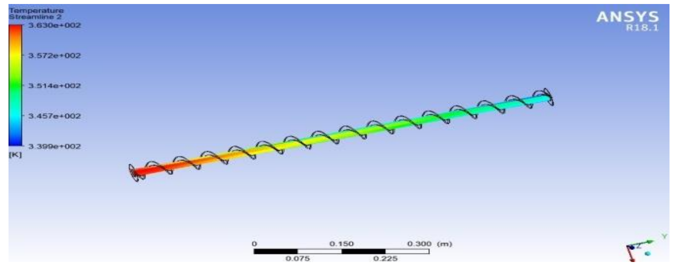

Fig5: Temperature distributions in helical fins (hot fluid)

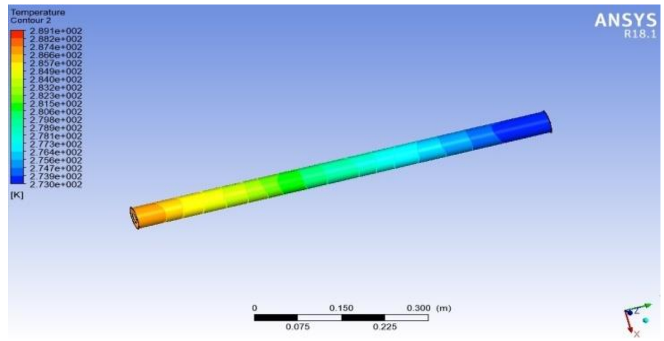

Fig 6: Temperature distributions in helical fins (cold fluid)

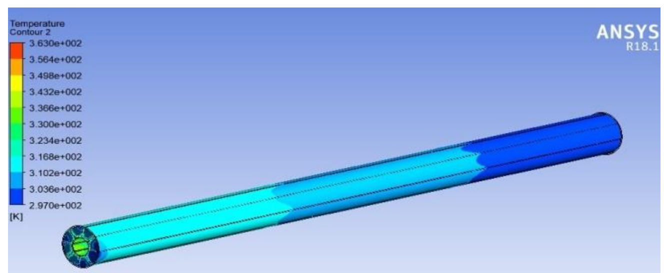

Fig 7: Temperature distributions in rectangular fins (cold fluid)

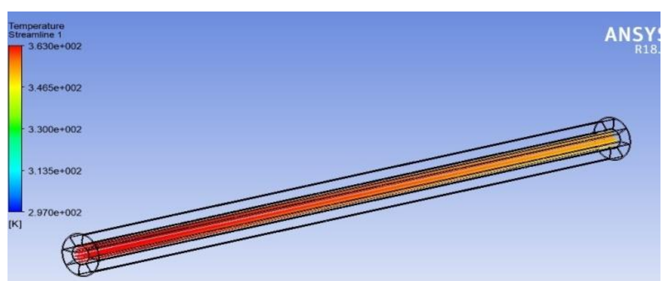

Fig 8: Temperature distributions in rectangular fins (hot fluid)

Figure 5, 6, 7, and 8 shows the temperature distribution of cold fluid and hot fluid of heat exchanger with helical and rectangular fins. While comparing the temperature distribution of cold fluid and hot fluid in helical and rectangular fins heat exchanger, where the helical fins heat enhancement technique gives more effective compared with other one.

B. PRESSURE DISTRIBUTION

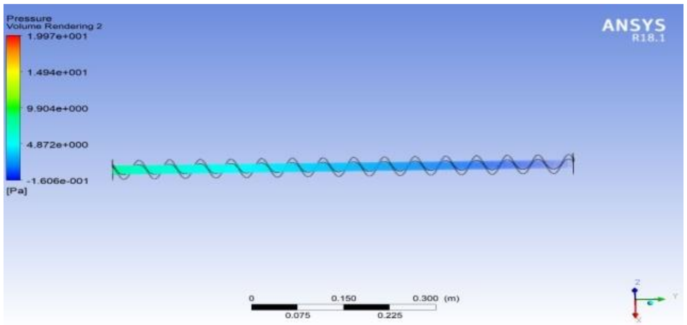

Fig 9: Pressure distributions in helical fins (hot fluid)

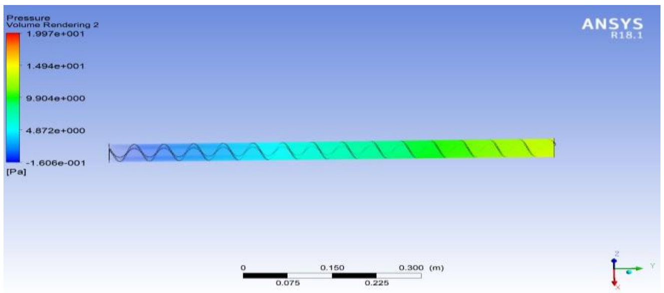

Fig10: Pressure distributions in helical fins (cold fluid)

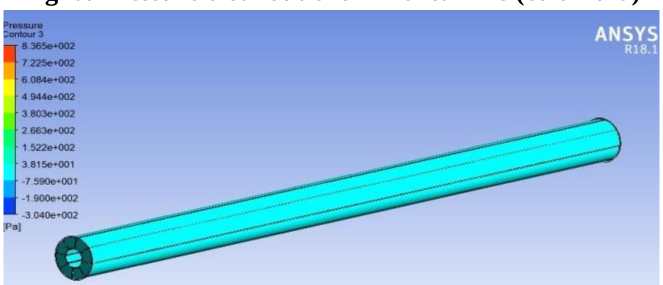

Fig11: Pressure distributions in rectangular fins (cold fluid)

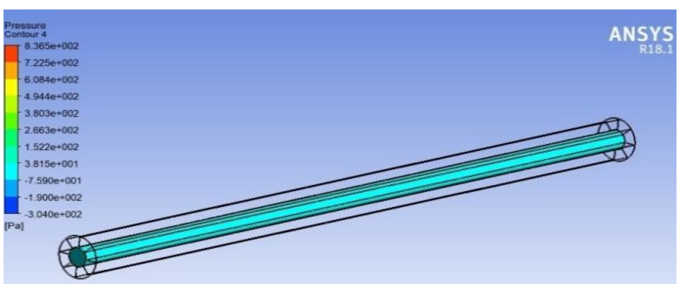

Fig 12: Pressure distributions in rectangular fins (hot fluid)

Figure 9, 10, 11 and 12 shows the pressure distribution in heat transfer enhancement methods. While comparing the pressure drop developing of cold fluid and hot fluid with helical and rectangular fins, where the pressure drop is high helical fins heat transfer enhancement technique compared with other one.

C. DATA REDUCTION

For the temperatures deviations, a log means temperature difference (LMTD)

$$LMTD = \frac{[(Tw,h,in - Tw,c,in) - (Tw,h,out - Tw,c,out)]}{\ln[\frac{Tw,h,in - Tw,c,in}{Tw,h,out - Tw,c,out}]}$$

$$LMTD = \frac{[(Tw,h,in - Tw,c,out) - (Tw,h,out - Tw,c,in)]}{\ln[\frac{Tw,h,in - Tw,c,out}{Tw,h,out - Tw,c,in}]}$$

Heat transferred to the cold water in the annulus, Qw,c, can be determined from,

$$Q_{w,c} = m_{w,c} C_{p,w}(T_{w,c,out} - T_{w,c,in})$$

Heat transferred from the hot water in the inner pipe, Qw,h, can be determined as

$$Q_{w,h} = m_{w,h} C_{p,w}(T_{w,h,in} - T_{w,h,out})$$

The average heat transfer rate, Qave, is determined from the hot water side and cold water side as

$$Q_{ave} = \frac{Qw,c + Qw,h}{2}$$

V. RESULTS AND DISCUSSION

The comparison of heat transfer enhancement and pressure drop are presented in Figure is related between helical fin and rectangular fin with different velocities in double pipe heat exchangers.

The following tables are explained the comparisons of heat transfer enhancement between two enhancement techniques having velocities are 0.2, 0.4, and 0.6 m/s. It also explains heat transfer rate and pressure drop with 25 °c as inlet temperature of cold fluid and 90°c as inlet temperature of hot fluid.

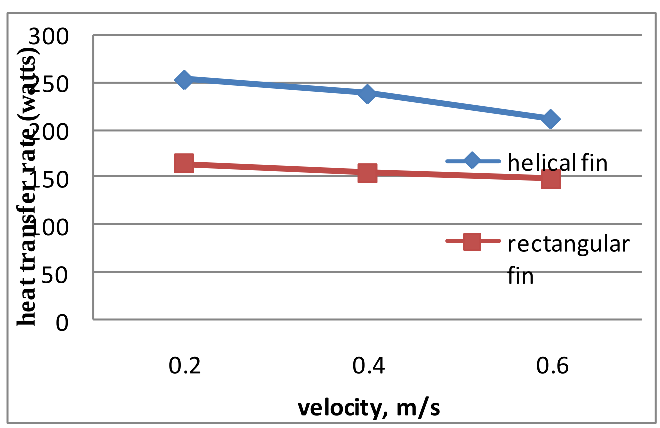

Table 1: Heat transfer rate in helical and rectangular fins

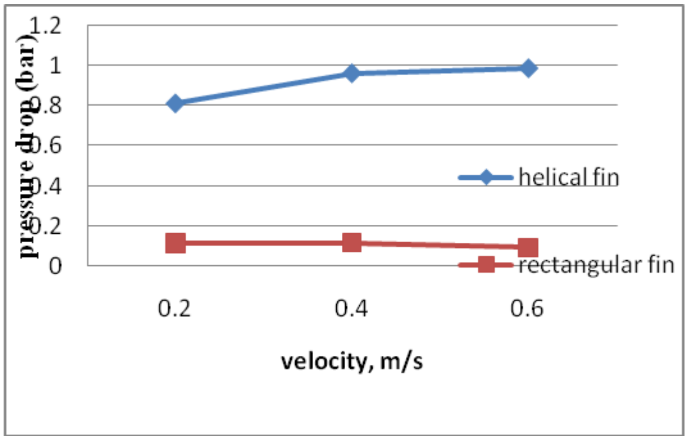

Table 2: pressure drop in helical and rectangular fins

A. EFFECTIVENESS

The comparison of effectiveness for helical and rectangular fin in double pipe exchanger is discussed as below. As seen in Figure, the behavior of effectiveness can be descending or ascending or a combination of both of them.

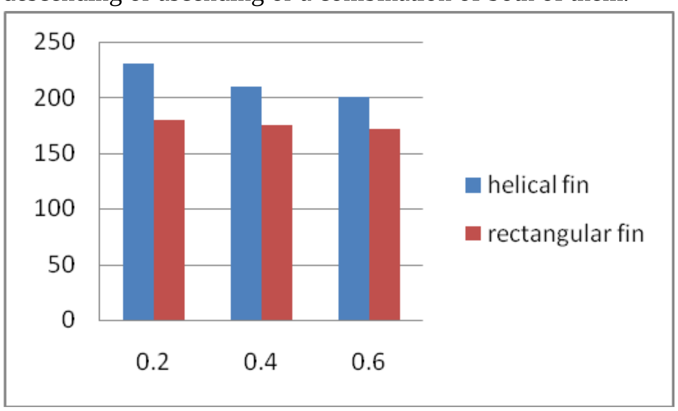

Table 4: Efficiency of heat transfer rate

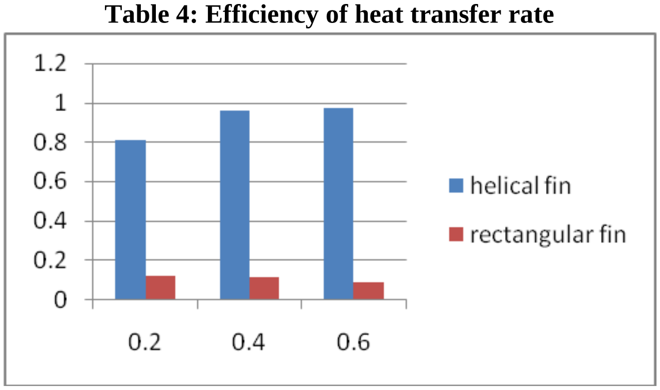

Table 5: Efficiency of pressure drop

As shown above tables. It is presented the relation of rate of heat transfer between the helical and rectangular fins. Here, the rate of heat transfer is increased 55% to 70% between them.

B. QUANTITATIVE RESULTS

The below table shows the comprehensive results of the heat exchanger with helical fins and rectangular fins with different velocities.

Variables		Velocity = 0.2 m/s		Velocity = 0.4 m/s		Velocity = 0.6 m/s	
		Helical fin	Rectangular fin	Helical fin	Rectangular fin	Helical fin	Rectangular fin
Inner pipe temp. (k)	Inlet	363	363	363	363	363	363
	outlet	339	345	342	351	348	356
Outer pipe temp. (k)	Inlet	298	298	298	298	298	298
	outlet	328	316	324	314	322	310
Rate of heat transfer, (watts)		252.61	164.53	238.65	154.62	212.46	148.62
Pressure drop (bar)		0.812	0.126	0.961	0.115	0.976	0.092

Table 6: Quantitative results

From the above table comparing all the variables with helical and rectangular fins where the helical fin pitch 4.5mm shows the increased value. The results show that the heat transfer coefficient has increased significantly in the pipe with helical fins. The increased pressure is observed at the inlet and pressure decreases gradually towards the outlet. The pressure distribution shows that increased pressure at inlet of helical fins and when flow continues the pressure drop is also more in this case. The outer models show that reduced pressure rise at the inlet

VI. CONCLUSION

Thus the performance analysis of heat exchanger with helical and rectangular fins has been carried out using CFD tool CFX and following conclusion has been drawn In this experiment Effectiveness is higher for helical fins used heat exchanger than rectangular fins used heat exchanger when compared to corresponding. Nearly 40% increased in heat transfer rate and 14% increase in pressure drop. The CFD simulation process results are showed in the temperature distribution and heat dissipation in the flow process. CFD flows are generated in maximum pressure flow generating in velocity regions.

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