THERMAL ANALYSIS OF HELICALLY GROOVED COIL IN A CONCENTRIC TUBE HEAT EXCHANGER

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ABSTRACT

The analysis of temperature distribution is considered in this paper by using a helically grooved coil in concentric tube heat exchanger. As the purpose of heat exchangers are increasing this paper deals about the theoretical and economical analysis by considering the helically grooved coil as inlet pipe with different materials such as aluminium, copper, carbon steels by maintaining the same inlet and outlet fluids with same velocities for all the materials. Comparisons have been taken by considering the flow as turbulent in the heat exchanger. The inner tube was helically grooved in which the area can be extended. The complete analysis is done by using ANSYS workbench. Heat transfer rate and temperature distribution are discussed

Key words: Helical coil, Convective heat transfer, unstable flow, Transient heat transfer, concentric tube heat exchanger.

Nomenclature:

A_i	*surface area of inner tube*
C	*Specific heat (J/Kg-K)*
k	*Thermal conductivity(w/m-k)*
Q	*heat transfer rate (KW)*
T	*Temperature (K)*

Introduction

Heat exchangers are the common equipment which are having major applications in power generation plants, many chemical industries, production of solar energy, for processing of food and also other energy intensive industries The design of an efficient heat exchanger had always been important to equipment designers. Due to their compact structure corrugated pipes are one of the method to increase heat transfer improvement technique and so these are used in industrial applications. As the effectiveness depends upon the rate of heat transfer, the effectiveness is directly proportional to the surface area by which the heat transfer takes place. Therefore, the heat transfer rate can be maximize by increasing the surface area of the tube such as by adding twisted tapes, by arranging additional surfaces by means of corrugation in it. In this paper, the helically grooved coil tube is considered as the inner tube to increase the surface area in concentric tube heat exchanger. Due to the helically groove in the coil the surface area is increased by having a turbulent flow by which the heat transfer rate is increased. Comparisons are taken to the helically grooved coil inlet pipe by changing the inlet materials of the pipe. As aluminium, copper and carbon steel are good in thermal conductivity and in other properties these are considered as inner pipe materials and steel is considered as the material for outer pipe. Vapour is used as inlet fluids where the water is used as the outlet fluid. The thermal analysis and temperature distribution is compared for all the cases and differences are considered.

Literature:

By twisting the tube the alteration of the flow can be varied by centrifugal forces stated by zachar as many studies were conducted to study heat transfer rate of coiled heat exchangers in laminar disorderly flows and modified twisted tapes were enhanced in order to increase the heat transfer by considering spirally corrugated wall. Many authors investigated experimentally the turbulent flow at dissimilar prandtl numbers and also turbulent forced convection heat transfer of nano fluids by twisted tapes. Depending upon the different flow zones it became highly important to increase heat transfer rate by many active techniques for various types of pipes by various methods. In case of passive techniques heat transfer can be increased by corrugation or by considering helical pipes and are investigated through laminar forced convection and thermal radiation in helical pipe explained by B. Zheng In order to increase the effectiveness of heat exchangers the study is also considered with nano fluids and verified the heat transfer rate is increased by adding the blocks to the walls of the tubes by which the surface of the pipe can be extended. The assumption of friction factors and heat transfer coefficients can increased by corrugated tubes combined with twisted tapes was experimentally given by V. Zimparov. Heat transfer and pressure drop in helically dimpled tubes and mixed convection heat transfer and isothermal pressure drop in corrugated tubes for laminar and transient flow. The friction factor and heat transfer rate were numerically analysed and calculated by considering nano fluids in order to increase the heat transfer rate. Corrugated coiled tubes were considered and experimental analysis, is performed by the multiple convective heat transfer in order to increase the heat transfer rate in a helically coiled wall corrugated tube. Forced convection was also discussed to compare the factors like friction factor and Reynolds number with different corrugation ratios. In order to increase the heat transfer rate in heat exchangers twisted oval tubes and also corrugated tubes were also discussed by using CFD in 3D. Amol Andhare investigated the performance of a shell and coil heat exchanger by considering helical pipes in it with counterflow in which the convective heat transfer is calculated by using Wilson plots and the process runs by considering curvature to pitch ratio. In this work the helically grooved coil is considered as inner pipe of the concentric tube heat exchanger in which the dimensions are considered from the base paper and the heat exchanger is designed and the comparisons are taken for the different materials considered.

Geometry of the file:

In this paper by using Rhinoceros 4.0 software the design of the geometry is done and the design is completed by various commands and is imported to the tool of Ansys workbench15 and by choosing option Fluid flow (Fluent).

Analysis:

The design geometry was labelled as various cases were considered for the material of the flow inside the pipe. In the meshing model of fluent panel the imported geometry is finely meshed. After that the boundary conditions were specified by naming the boundary, wall, inlet for inner and outer pipes and outlet for inner and outer pipes has to be specified in the meshing window. In the transient state the study of heat exchanger takes place by considering the flow of fluid as turbulent. The design model selected were energy k-ϵ(2-eqn) in the heat exchanger. Velocity of the fluid will be same for all the cases and can be obtained heat transfer analysis through those equations. The flow of the fluid in the heat exchanger is considered as parallel flow in the heat exchanger and the analysis was analyzed by Ansys Fluent.

Results and discussions:

Comparing the obtained results of the helically grooved coil with the three inner materials and they are obtained as follows:

Fig. 1 represents the temperature distribution in a helically grooved coil in which the inner material of the pipe is taken as aluminium and the outer pipe is steel in which air is considered as internal fluid and water is considered as external fluid. The temperature drops from 473K to 326K. The fig represents the contours at static temperature at certain temperature drop.

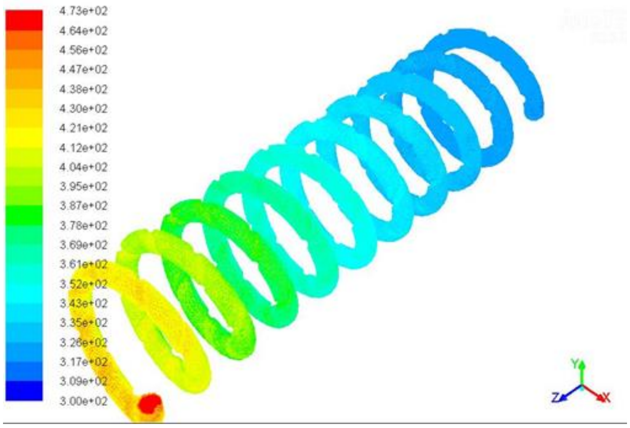


Fig: 3

Fig. 2 represents the temperature distribution in a helically grooved coil in which copper is considered as inner material and outer pipe material as steel in which the inner fluid is taken as steam and the outer fluid is water. The temperature drops from 473K to 317K.The fig represents the contours at static temperature at certain temperature drop.

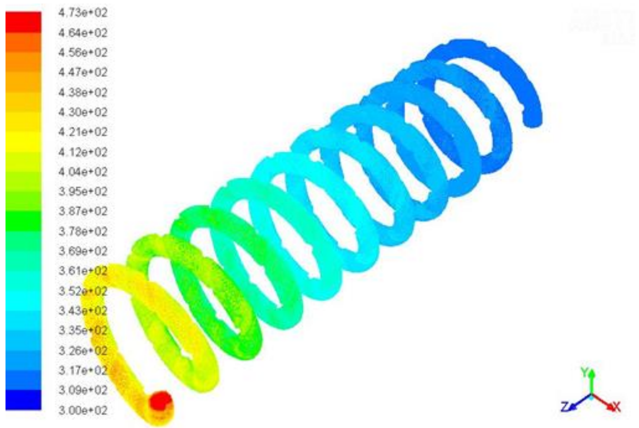


Fig: 4

Fig. 3 represents the temperature distribution in a helically grooved coil in which the inner material of the pipe is taken as aluminium and the outer pipe is steel in which steam is considered as internal fluid and water is considered as external fluid. The temperature drops from 473K to 307K.

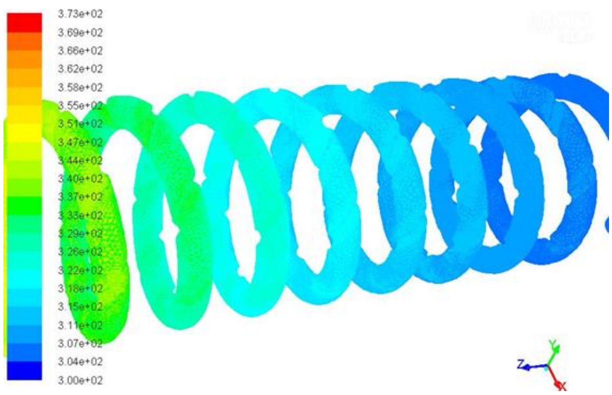


Fig: 5

Fig4 represents the temperature distribution in a helically grooved coil in which the inner material of the pipe is taken as carbon steel and the outer pipe is steel in which steam is considered as internal fluid and water is considered as external fluid. The temperature drops from 473K to 315K.

Fig: 6

Solutions:

By the analysis for the helically grooved coil pipe, initial conditions were taken as same. The results were as follows:

Temperature: (helically grooved coil pipe)

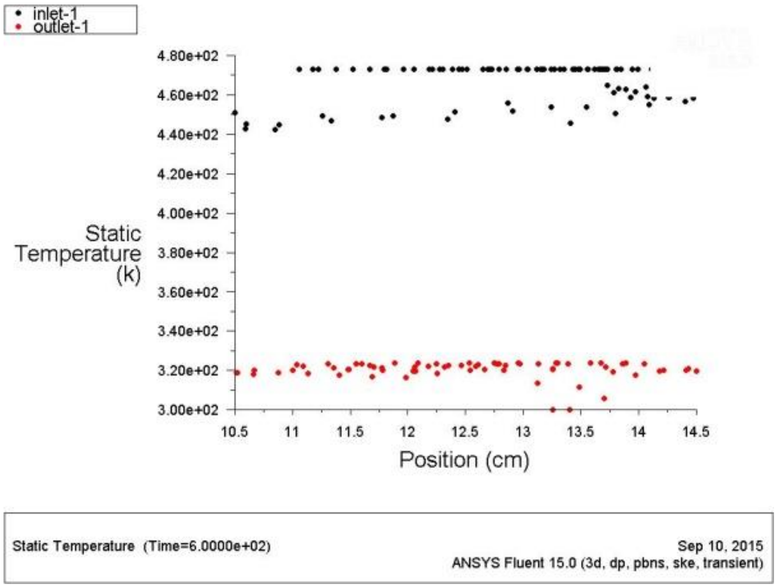
Case 1:
(Aluminium)Air as inlet : 473k
(Steel)Water as outlet : 326k

Case 2:
(Copper) Steam as inlet : 473k
(Steel)Water as outlet : 317k

Case 3:
(Aluminium) Steam as inlet : 473k
(Steel)Water as outlet : 309k

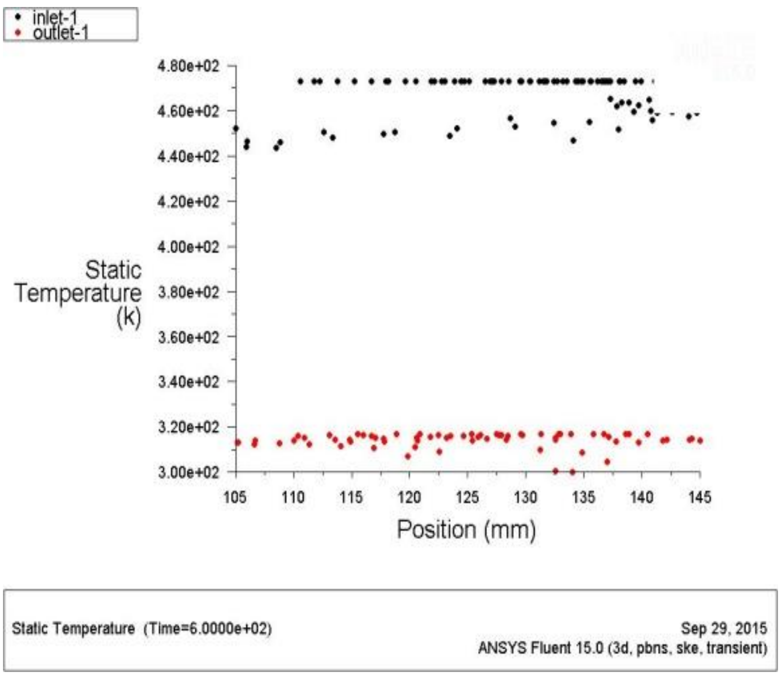
Case 4:
Carbon steel as inlet : 473k
Steel as outlet : 315k

Graph 1 represents the inlet and outlet temperature in which air is passed through inner pipe and water is passed through outer pipe in which the inner temperature is of 473K and outlet is 320K.



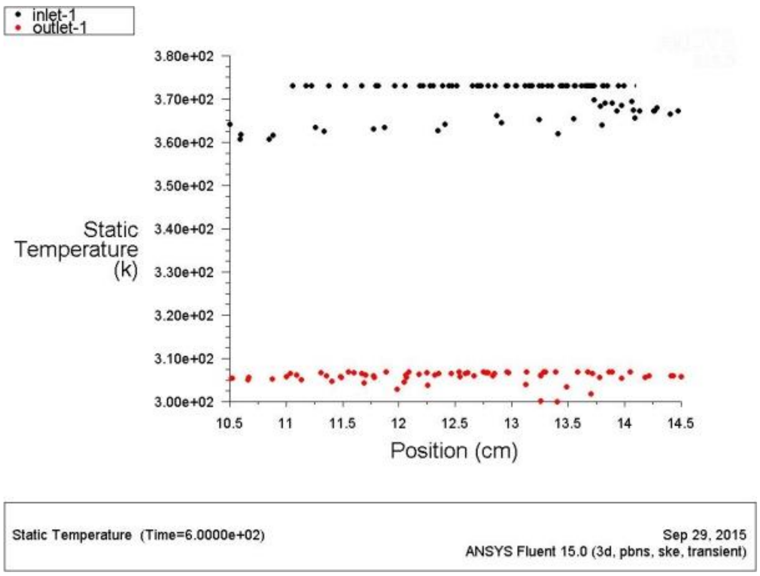
GRAPH 2

Graph2 represents the inlet and outlet temperature in which vapour is passed through inner pipe and water is passed through outer pipe in which the inner temperature is 473K and outlet is 317K



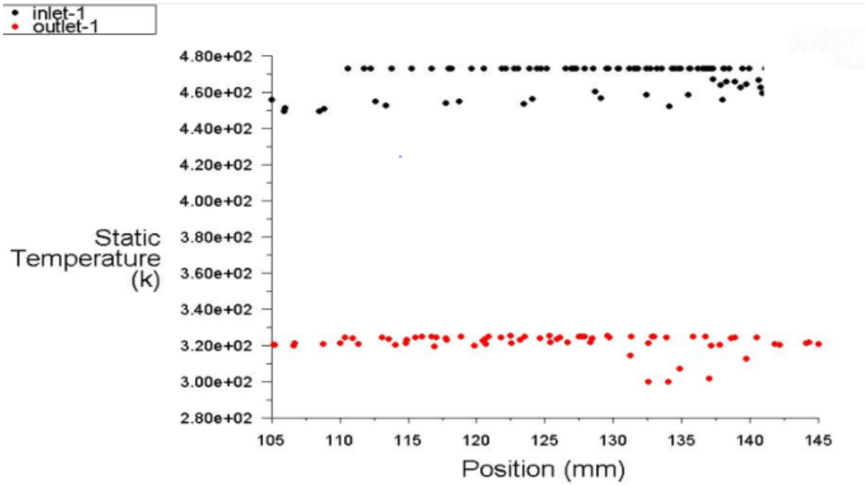
GRAPH 3

Graph 3 represents the inlet and outlet temperature in which vapour is passed through inner pipe and water is passed through outer pipe in which the inner temperature is 473K and outlet is 309K.



Graph 3

Graph 4 represents the inlet and outlet temperature in which carbon steel is considered as inner pipe material and steel is considered as outer pipe material in which the inner temperature is 473k and the outer temperature is 315k.



Graph 4

Conclusion:

An experimental analysis was carried out in a concentric tube heat exchanger for the study of heat transfer coefficient and temperature distribution. Helically grooved coil of three different inner materials were investigated for parallel flow configuration. From the comparisons with different inlet materials it was found that the helical groove with aluminium as inlet pipe material is highly preferred in order to increase the temperature distribution of a heat exchanger.

Future Scope:

The analysis of heat exchanger was obtained by considering helical coil as inner pipe and for application purpose it can be used in condensers, refrigeration process and thermal plants. By considering optimal pitch value the heat transfer rate can be increased and also by nano fluids the study of heat transfer rate and temperature distribution can be experimentally obtained.

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