Exprimental and Finate Element Analysis of Concentric Tube Heat Exchanger

B. Soundarya Santhoshi, P. Ramamurtyraju, S.Rajesh

Abstract : This paper deals with the concentric tube heat exchangers which are made of galvanized iron and copper materials. In this paper, three different L/D ratios (157.89mm, 98.91mm, 63.33mm) were considered for analyzing the parallel and the counter flow processes. ANSYS FLUENT software 14.5 is used to find the theoretical calculations and also to study the inlet temperature, velocity & pressure drops. These calculations are helpful to validate the efficiency of the concentric pipe heat exchanger and also to know how these values vary with each other. Computational Fluid Dynamics is used to asset the outlet temperature of both the counter and parallel flow heat exchangers. Finally the results were analyzed between both counter and parallel flow heat exchangers in order to identify the most efficient one .

***Keywords:** Heat exchangers, Parallel flow, Counter flow, Concentric Tube, CFD Analysis.*

I. INTRODUCTION

The heat exchangers are mechanical apparatus which are used to transfer the heat from more than two fluids. The fluids perhaps separated by a solid surface possible in direct contact or mixing. They are widely exploited in refrigeration, air conditioning, space heating, petrochemical plants, chemical plants, power stations and natural-gas processes. Heat exchangers are most commonly wornd equipment in the industries. Heat exchangers are utilized to transfer the heat from more than two process streams. One can recognize the utilization of any process which involves heating, boiling, evaporation, cooling and condensation will requires a heat exchanger for these purposes. The Process fluids are usually cooled or heated before the processes or undergoing a state change. Different heat exchangers are exploited their applications.

A common coordinate tube heat exchanger can have two pipes. One pipe placed commonly inside and another of extensive diameter with proper fittings to direct the flow from one region to another region. One fluid pour through the inherent pipe and other fluid pour through the annulated space. Concentric tube heat exchangers can form different parallel and counter arrangements to meet mean temperature difference and mean pressure drop requirements. The concentric pipe heat exchangers are one of the most familiar conductive - convection type of heat exchanger. It subsist of two tubes that are concentrically adjust each carrying one of the fluid (either hot are cold) for a concentric tube heat exchanger. Two form of flow arrangements are possible, counter and parallel flow. The flow direction of hot fluid will be same as the cold fluid. The flow directions of the cold and hot fluids are opposite to each other.

Sneha et al. [1] investigated "Computational Fluid Dynamics(CFD) is used to find the different pipe materials and done the parallel and counter flows. And also find the most In this ansys fluid software is used to find the double pipe heat exchangers and also find the most hard one is 5% using the ansys workbench. *Folaranmin et al.* [2] investigated LMTD is used to find the overall heat transfer cofficient. *Mayank et al.* [4] investigated the study dealswith CFD simulation of concentric tube heat exchanger is used find ansys results for steel and also find the finate element analysis using finate element tools . *compared the design and parallel flow of a heat exchanger. Suresh et al.* [5] investigated to compare experimental and numerical values of a concentric tube heat exchanger in the experiment the numerical simulation has been developed to investigate heat transfer enhancement in a modified convergent-divergent concentric tube heat exchanger. *Deepa Shrivastav et al.* [6] investigated the CFD based simulation carried out for Tube-in-Tube heat exchanger using ANSYS software. The CFD results for heat transfer characteristics are compared with result from the experimentation. *Deepak Kumar et al.* [7] in this study, authors calculated the heat transfer for three-pipe concentric heat exchanger and it was found to be greater than that for two-pipe heat exchanger. The higher heat transfer is because of the increase in area through which heat is transferred. Vindhya et al. [8] did the analysis of shell & tube of a concentric tube heat exchanger varying the different conditions. Sachchidanand et al. [9] to study the finite element analysis and optimization of concentric tube heat exchanger. Bhanuchandrarao et al. [10] to study the CFD analysis of concentric tube heat exchanger.

In this paper, we are done both parallel and counter flow heat exchangers using different length and diameter ratios. ANSYS fluent software is used to find the theoretical values and to study the inlet temperature drop and velocity drop using CFD analysis and to compare the both parallel and counter flows.

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II. EXPERIMENTATION

A concentric pipe heat exchanger has two concentric tubes. The inside pipe is made of copper and the inner tube is made of galvanized iron. A set of three concentric pipe heat exchangers are construct with the same materials. The materials properties of copper includes strength, conductivity etc. The material properties of galvanized iron include corrosion resistance, fatigue strength, etc. The copper an iron pipes are taken as per required diameters and lengths. They are designed in such a way that they allow flow of hot water and cold water in parallel and counter directions. The insulation is provide to the pipes so that there will be no heat loss to the surroundings. The thickness of copper pipe is taken as 1mm and GI pipe as 3mm. The experimentation setup was shown in below Fig. 1.

Fig-1 Experimental setup

PROCEDURE

The valve on the water main is opened and the water is let on to circulate over the heat exchangers. Thermometer is placed on both hot and cold fluids. Switched on electrical geyser and water is heated in it. The valve 5 is opened to allow the hot water from geyser.

(i) FOR PARALLEL FLOW: The valve 1and 2 are opened and valves 3 and 4 are closed, to cause both fluids to flow in the same direction. The valve 1 is having cold water is controlled to essential both fluids are following at the same amount (by using stopwatch and jar).

ii) FOR COUNTER FLOW: The valve 3and 4 are opened and valve 1and 2 are closed, to cause both fluids flow in the different way. The valve 3 is having cold water is controlled to essential both fluids are following at the same amount (stopwatch and jar).To collect the 1000 ml of water, at the study state, temperature and timing and to note the valves of both cold and hot fluids. The experiment procedure is repeated.

III. MODELING AND ANALYSIS

A. Model

Model is created in CATIA and imported to ANSYS workbench. The meshing of geometry performed in ANSYS Workbench. The geometric standard of the concentric pipe heat exchangers is demonistrated as below Fig. 2

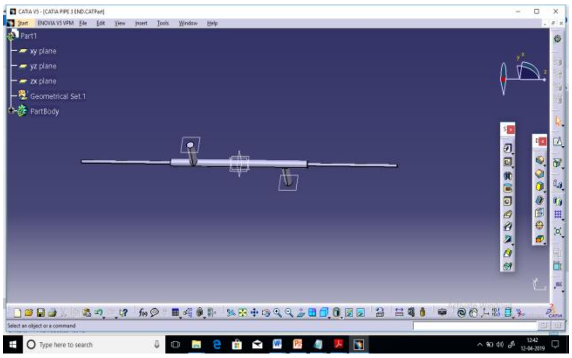

Fig-2 Geometric model of concentric tube heat exchanger

B. Meshing

Meshing is produced the most appropriate mesh for accurate, efficient multi physics solutions. Initially a relatively coarser mesh is generated with million cells. This mesh contains different cells (tetra and hexahydralcells). The meshing Fig-3 is shown below.

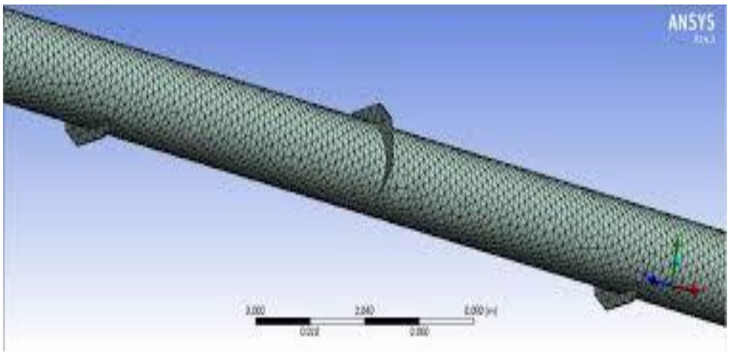

Fig – 3 Meshing of a concentric tube heat exchanger

C. Boundary conditions

Inlet temperature (Th_1) = 71 ^oC
Outlet temperature (Tc_1) = 34 ^oC
Mass flow rate = 460 ml/min
Overall heat transfer coefficient = 449.62 W/m^2-K
Wall thickness =1mm
Inlet temperature (Th_2) = 64^oC
Outlet temperature (Tc_2) = 48^oC
Mass flow rate = 460 ml/min
Overall heat transfer coefficient = 449.62 W/m^2-K
Wall thickness = 1mm

IV RESULTS AND DISCUSSIONS

A. Velocity Distribution

The input values are given to the required pipe. Blue color represents the low velocity and red color represents the higher velocity of the given heat exchanger. As demonistrated as below Fig-4.

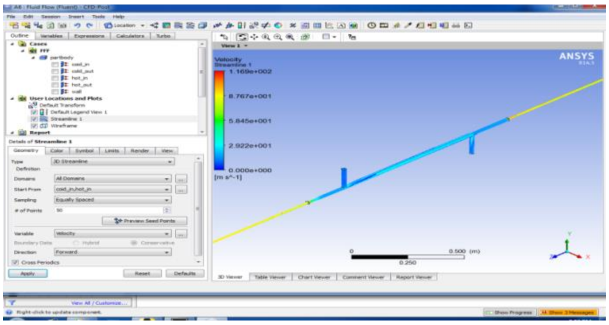

Fig-4 velocity distribution over the pipe

B. Temperature distribution

In this plot, blue color indicates the low temperature and red color indicates the higher temperature of the given heat exchanger as demonistrated as below Fig-5.

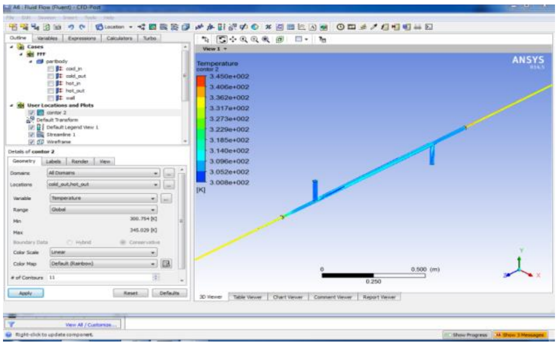

Fig- 5 Temperature distribution over the pipe

C. Pressure distribution

In this plot, blue color indicates the low pressure and red color indicates the higher pressure of the heat exchanger demonistrated as Fig -6.

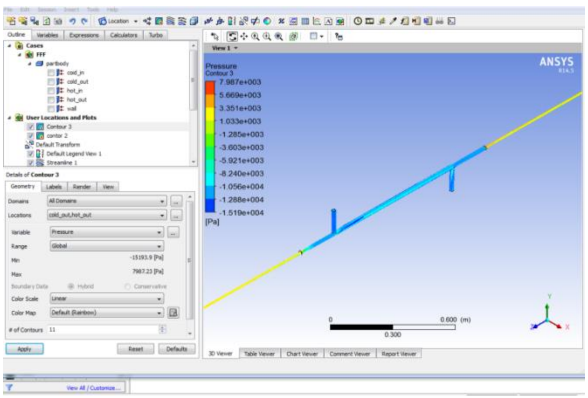

Fig-6 Pressure distribution over the pipe

Parallel and counter flows having different length and diameter ratios. ANSYS fluent software is used to find the velocity, temperature, and pressure distributions. The results are compared with both the theoretical and experimental values and to find the effectiveness using mass flow rate and overall heat transfer coefficient. The results were shown in table 1.

Table 1: Theoretical and Practical values of concentric tube heat exchanger

L/D ratio (mm)	Mass flow rate (ml/min)	Overall heat transfer coefficient U (W/m^2-K)	Effectiveness (Theoretical)	Effectiveness (Experimental)
63.33	850	704.04	0.375	0.345
98.91	850	516.776	0.28	0.343
157.89	850	565.9	0.272	0.339

Comparing the three different L/D ratios, it is noticed that L/D ratio of 157.89 mm is more efficient than the reaming two L/D ratios. The comparison is shown in below Fig 7.

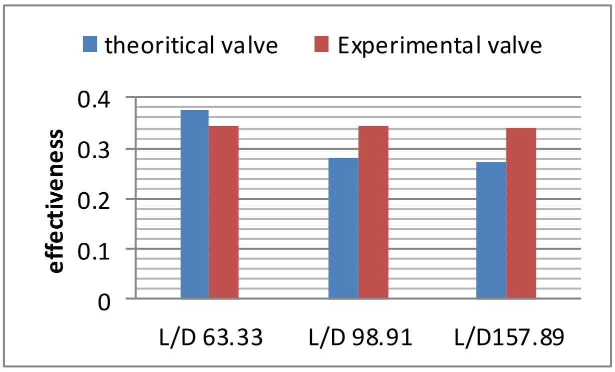

Fig-7: Comparison between Theoretical and Experimental values using different L/D and effectiveness

V CONCLUSIONS

It is observed that the working principles such as effectiveness and overall heat transfers coefficient of L/D=157.89 mm concentric pipe heat exchangers is better to compared the other two L/D ratios and also comparing the both counter & parallel flows, counter flow heat exchangers is more efficient.Hence the concentric pipe heat exchanger of L/D=157.89 is most efficient than the other two heat exchangers.

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