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Analyses of the Experimental and Finite Elements of a Concentric Tube Heat Exchanger

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Abstract: This article discusses concentric tube heat exchangers constructed of galvanised iron and copper. Three alternative L/D ratios (157.89mm, 98.91mm, and 63.33mm) were used in this work to analyse parallel and counterflow processes. The theoretical calculations are performed using ANSYS FLUENT 14.5 software, as are the inlet temperature, velocity, and pressure decreases. These calculations are beneficial for validating the concentric pipe heat exchanger's efficiency and also for determining how these values differ from one another. The output temperature of both counter and parallel flow heat exchangers is calculated using computational fluid dynamics. Finally, the findings were compared to those obtained from counter and parallel flow heat exchangers to determine which was the most efficient.

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

I. INTRODUCTION

Heat exchangers are mechanical devices that are used to transfer heat between several fluids. The fluids may be separated by a solid surface and may come into touch or mix. They are extensively used in refrigeration, air conditioning, and space heating, as well as in petrochemical and chemical industries, power plants, and natural gas operations. Heat exchangers are the most often used piece of equipment in enterprises. Heat exchangers are used to transmitting heat between several process streams. Any process that includes heating, boiling, evaporation, cooling, or condensation will necessitate the use of a heat exchanger. Typically, process fluids are chilled or heated before performing a process of experiencing a state transition. Numerous heat exchangers are used in their various applications.

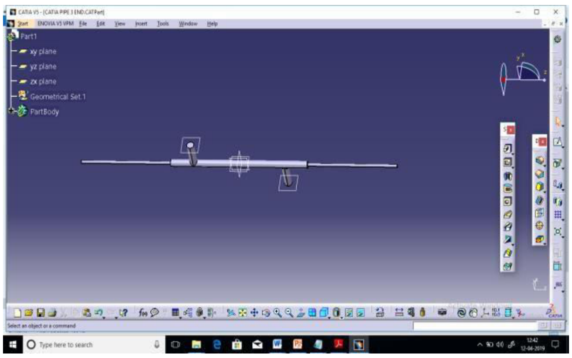
Two pipes may be found on a standard coordinate tube heat exchanger. One pipe is often installed inside, while another with a large diameter and the appropriate fittings is used to guide the flow from one location to another. One fluid enters the intrinsic pipe, while the other enters the annulated space. Concentric tube heat exchangers may be configured in a variety of parallel and counter-flow configurations to suit requirements for mean temperature difference and mean pressure drop. Concentric pipe heat exchangers are a rather common form of the conductive - convection heat exchanger. It is composed of Two concentrically adjusted tubes, each conveying one of the fluids (hot or cold), are used in a concentric tube heat exchanger. There are two conceivable flow configurations: counterflow and parallel flow. The direction of flow of hot fluid will be identical to that of cold fluid. The flow directions of cold and hot fluids are opposed.

Sneha et al. [1] studied "Computational Fluid Dynamics (CFD) is utilised to determine the various pipe materials and perform parallel and counterflows." Additionally, locate the most Using the Ansys workbench, this Ansys fluid programme is used to locate twin-pipe heat exchangers and also to locate the most difficult one is 5%. Folaranmin et al. [2] examined the LMTD method for determining the total heat transfer coefficient. Mayank et al. [4] studied the research deals with CFD simulation of a concentric tube heat exchanger is utilised to determine the Ansys findings for steel and also to determine the finite element analysis utilising finite element tools. contrasted the heat exchanger's design and parallel flow. Suresh et al. [5] compared experimental and numerical results for a concentric tube heat exchanger in the experiment and built a numerical simulation to study heat transfer enhancement in a modified convergent-divergent concentric tube heat exchanger. Deepa

Shrivastav et al. [6] studied the use of ANSYS software for CFD simulations of Tube-in-Tube heat exchangers. The computational fluid dynamics (CFD) findings for heat transport characteristics are compared to the experimental data. Deepak Kumar et al. [7] calculated the heat transfer coefficient for a three-pipe concentric heat exchanger and found that it was larger than that for a two-pipe heat exchanger. The increased heat transmission is due to the increased surface area across which heat may be transported. Vindhya et al. [8] analysed the shell and tube of a concentric tube heat exchanger under various operating situations. Sachchidanand et al. [9] analysed and optimised a concentric tube heat exchanger using finite element analysis. Bhanuchandrarao et al. [10] did a computational fluid dynamics analysis of a concentric tube heat exchanger.

II. XPERIMENTATION

There are two concentric tubes in a heat exchanger with concentric tubes in the arrangement. Both the inner tube and the copper inner pipe are galvanised iron. The same materials are used to build a trio of concentric pipe heat exchangers. Strength, conductivity, etc. are only a few of the copper's material attributes. Galvanized iron's material qualities include corrosion resistance, fatigue strength, and more. The sizes and lengths of the copper and iron pipes are chosen to suit the project's specific needs. Pipe insulation prevents heat from escaping into the surrounding environment. Copper pipe is assumed to be 1 mm thick, whereas GI pipe is assumed to be 3 mm thick. Experimentation is shown in the diagram below.



B. Meshing

Fig-2 Geometric model of concentric tube heat exchange

Fig-1 Experimental setup

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PROCEDURE

The water main valve is opened, allowing water to pass across the heat exchangers. On both hot and cold fluids, the thermometer is put. An electrical geyser is activated and water is heated in it. Valve 5 is opened to enable the geyser to produce hot water.
I FOR PARALLEL FLOW: Open valves 1 and 2 and shut valves 3 and 4, causing both fluids to flow in the same direction. Valve 1 is managed to ensure that both fluids flow at the same rate (by using a stopwatch and jar).
ii) FOR COUNTER FLOW: Valves 3 and 4 are opened, while valves 1 and 2 are closed, causing the two fluids to flow in opposite directions. Valve 3 is managed to ensure that both fluids flow at the same rate (stopwatch and jar). To collect 1000 mL of water in the research state, temperature, and timing conditions, and to take note of the valves for both cold and hot fluids. The process for the experiment is repeated.

The best suitable mesh is generated for precise, efficient multiphysics solutions. Initially, a mesh containing millions of cells is formed. This mesh is composed of many cells (tetra and hexahedral cells). Fig-3 illustrates the meshing process.

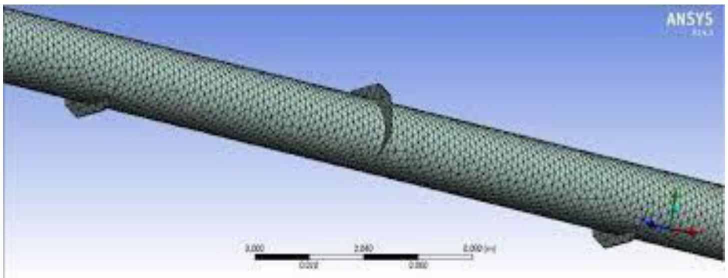


Fig – 3 Meshing of a concentric tube heat exchanger

C. Boundary conditions

Temperature at the inlet (Th1) = 71 oC
Temperature at the outlet (Tc1) = 34 oC
460 ml/min mass flow rate
Coefficient of heat transmission in total = 449.62 W/m2-K 1mm wall thickness
Temperature at the inlet (Th2) = 64oC
Temperature at the outlet (Tc2) = 48oC 460 ml/min mass flow rate
Coefficient of heat transmission in total = 449.62 W/m2-K 1mm wall thickness

IV RESULTS AND DISCUSSIONS

A. Velocity Distribution

A. Model

III. MODELING AND ANALYSIS

All of the necessary pipes are fed with the corresponding input values. The heat exchanger has a blue colour for low velocity and a red hue for high velocity. As seen in the figure below, Fig. 4.

CATIA is used to construct the model, which is then loaded into the ANSYS workbench. Geometry meshing is carried out in ANSYS Workbench. The geometric specification for concentric pipe heat exchangers is shown in Figure 2.

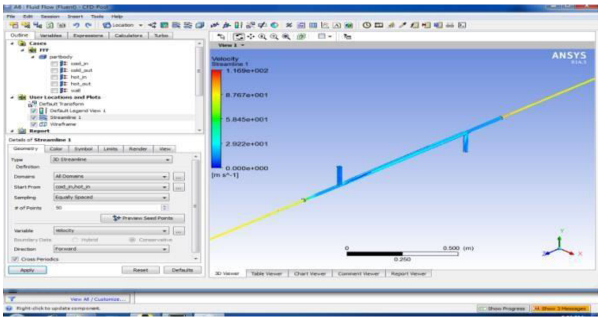


Fig-4 velocity distribution over the pipe

B. Temperature distribution

The lower the blue hue, the lower the heat exchanger's temperature; the higher the red colour, the higher the heat exchanger's temperature, as shown in Fig. 5.

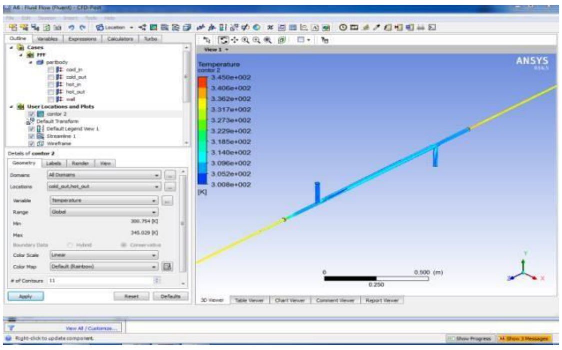


Fig- 5 Temperature distribution over the pipe

C. Pressure distribution

The heat exchanger shown in Fig. -6 has a low-pressure blue line and a high-pressure red line in this graph.

Fig-6 Pressure distribution over the pipe

With varied length and diameter ratios in each flow. The velocity, temperature, and pressure distributions are calculated using ANSYS fluent software. Mass flow rate and the total heat transfer coefficient are used to compare the findings with theoretical and experimental values and determine the efficacy. Table 1 displayed the findings.

Table 1: Practical values of concentric tubeheat exchanger

L/D ratio (mm)	Mass flow rate (ml/min)	Overall heat transfer coefficie nt U (W/m^2-K)	Effectivenes s ss (Theoretical)	Effectiveness (Experimenta l)
63.33	850	704.04	0.375	0.345
98.91	850	516.776	0.28	0.343
157.8 9	850	565.9	0.272	0.339

With this L/D ratio, the other two L/D ratios are found to be less efficient. Contrast is seen in Fig. 7.

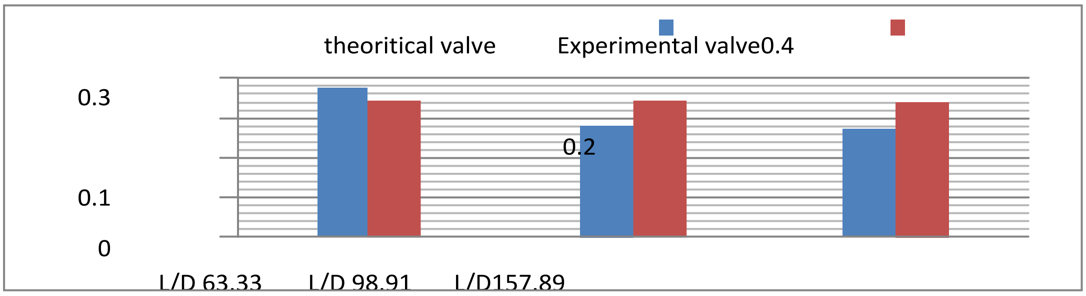
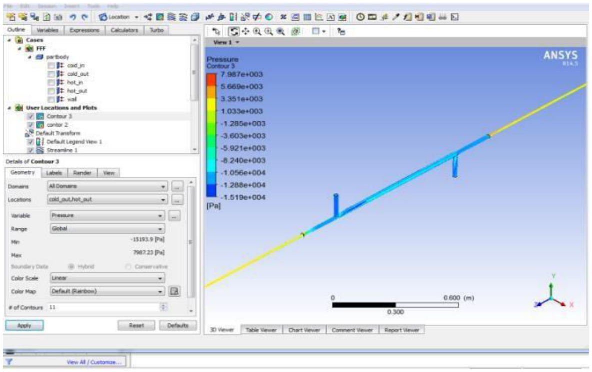


Fig-7: Comparison between Theoretical and Experimental values using different L/D and effectiveness



V CONCLUSIONS

This study found that L/D=157.89 mm concentric pipe heat exchangers perform better than the other two L/D ratios, and counter flow heat exchangers are more efficient than parallel-flow heat exchangers when comparing the two flows. It is thus more efficient to use the concentric pipe heat exchanger of L/D=157.89 than the other two.

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