RESEARCH ARTICLE OPEN ACCESS

"A Comparison of Shell and Tube Type Heat Exchanger by Experimental and CFD Analysis"

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ABSTRACT
The In these researches work a shell and tube type single pass heat exchanger considered for the comparative analysis. Analysis has been perform in two different phases, in first phase we prepare one setup of shell and tube type heat exchanger with brass tube for shell and cold water for straight copper tube of 500 mm for hot water due to its good thermal conductivity. After the experimental study a computational fluid dynamic analysis was perform by creating a virtual model in CFD environment. The CFD model has created according to the physical parameter of experimental setup and same boundary condition has provided to analysis the performance of heat exchanger. The solution obtained for each combination of velocity and temperature input and corresponding output is stored in the form of solution table and graph. After the CFD analysis a comparative study has been performed to know the effectiveness of heat exchanger.

Keywords – Computational Fluid dynamic (CFD), Spatial Discretization (SD)

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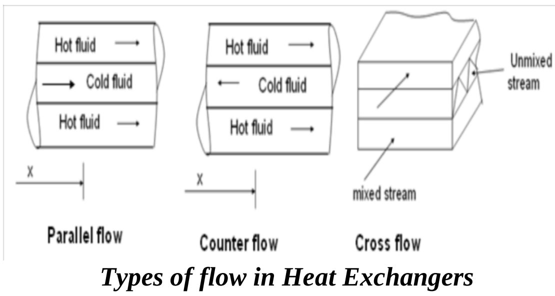
I. INTRODUCTION

A heat exchanger is a device built for efficient heat transfer from one medium to another medium. The media may be separated by a solid wall, so that they never mix, or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, cryogenics applications and sewage treatment. One common example of a heat exchanger is the radiator in a car, in which the heat source, being a hot engine-cooling fluid, water, transfers heat to air flowing around the radiator (i.e. the heat transfer medium).

The heat exchanger accepts two or more streams, which may flow in directions parallel or perpendicular to one another. When the flow directions are parallel, the streams may flow in the same or in opposite sense. Thus we can think of three primary flow arrangements:[13]

a) Parallel flow
b) Counter flow
c) Cross flow

Thermodynamically, the counter flow arrangement provides the highest heat (or cold) recovery, while the parallel flow geometry gives the lowest. The cross flow arrangement, while giving intermediate thermodynamic performance, offers superior heat transfer properties and easier mechanical layout. Under certain circumstances, a hybrid cross counter flow geometry provides greater heat (or cold) recovery with superior heat transfer performance. Thus in general engineering practice, plate fin heat exchangers are used in three configurations: (a) cross flow, (b) counter flow and (c) cross-counter flow.



Types of flow in Heat Exchangers

II. PROBLEM FORMULATION

Effectiveness of heat exchanger can be increased without significant change in the circuit is possible by only one way i.e. by increasing flow of cold fluid in the inlet valve. However if we increase the flow in cold inlet in the tube type Heat Exchanger, then characteristics goes down which could be balanced by decreasing no. of tube of Heat Exchanger and decreasing the relative velocity of fluids flowing in Tube Type Heat Exchange.

Experimental setup of HE

Property of Material of Heat Exchanger

Property	***Steel***	***Copper***	***Brass***
Density (kg/m3)	***7.87E+03***	***8.96E+03***	***8.60E+03***
Poisson's Ratio	***0.27-0.30***	***0.34***	***0.331***
Thermal Conductivity (W/m-K)	***59.5***	***401***	***115***
Specific Heat (J/kg-K)	***481***	***385***	***375***

III. EXPERIMENTAL ANALYSIS

An experimental setup is prepare to perform the research work in laboratory. The setup consists of a single-phase heat exchanging system in which hot water passes through the straight tube and it exchanges heat by cold water flows inside the shell side. The heat exchanger includes an insulated cylindrical shell which is equipped with a copper straight tube.

Specification of Shell and Tube Type Heat Exchanger

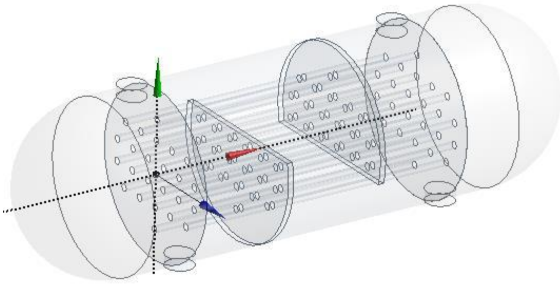
S.No.	*Parameter Name*	*Size in mm*
1	Total length (mm)	1000
2	Length of shell (mm)	500
3	Diameter of shell (mm)	300
4	Length of tubes (mm)	500
5	Diameter of tubes (mm)	12.7
6	Number of tubes	24
7	Radius of curvature of cover end plates (mm)	390
8	Inlet and outlet port diameter	50.8
9	Distance of inlet and outlet port from the shell end (mm)	50
10	Pitch distance between consecutive tubes (mm)	38.6
11	Baffle thickness (mm)	10
12	No. of baffles	2
13	Distance of baffles from the shell ends (mm)	156.6

IV. COMPUTATIONAL FLUID DYNAMIC ANALYSIS

Modelling & Meshing of Tube Geometry

In order to create the solid model of tube geometry we again start with the sketching of the both dome end and maintain the space between them as 500 mm for tube. The curvature of dome is randomly taken as 390 mm to maintain the overall size of heat exchanger. Total 24 tube has been modelled between the both end of dome and each having internal and outer diameter as 10 mm and 12.7 mm.

Here we assign the different material for tube, shell and outer body of HE. For these analyses we assign copper to the tube and brass for shell inner tube and outer body of HE assign as structure steel. Generally the engineering materials are available in ansys material library but in case if it is not in library then we can also create it by using its mechanical property.



Geometry of heat exchanger

Boundary Condition Heat Exchanger

The term boundary condition deal with the actual condition or environment of working of heat exchanger. Here we are using hot and cold water as a media to flow in shell and tube to transfer the heat from hot to cold fluid. When the hot fluid come into the tube its temperature is 60 °C which is higher and

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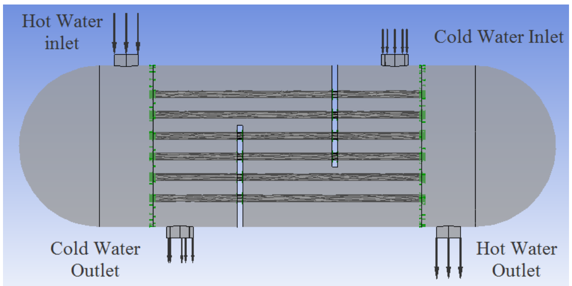
it comes down when it comes in contact with the cold fluid in heat exchanger. The thermal condition of both fluids is given in the table below

Properties of Flowing Fluids

S No	Name Of Fluid	Boundary Condition Type	Value
1	Hot water	Inlet Velocity	0.5 m/s
		Inlet Temperature	65° C
		Initial Pressure	1 atm
2	Cold water	Inlet Velocity	1 m/s
		Inlet Temperature	25° C
		Initial Pressure	1 atm



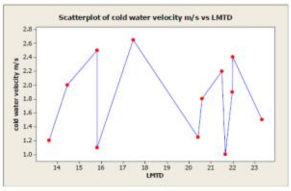
Boundary condition of Helical coil Heat Exchanger

V. RESULT & DISCUSSION

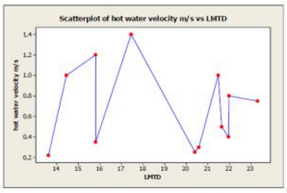
Experimental Result of Shell and tube Type Exchanger

After the experimental procedure we get different set of result in the form of combination of inlet velocity and temperature for cold and hot fluid. The detail of inlet and out let temperature is given in the table below. After the critical analysis of the result we found that the heat transfer rate in increases due to increase the inlet velocity of the cold fluid and when we increase the velocity of hot fluid there is significant change in the temperature of outlet hot fluid. Similarly the value of LMTD is high for first two and last three experiment and for rest of experiment its nature is irregular. For experiment Number 6 and 8th the value of LMTD is almost same for both the combination of inlet velocity and temperature of hot and cold fluid.

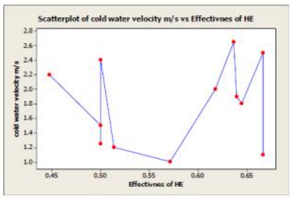
The overall effectiveness of the heat exchanger is lie in between the value of 0.51 to 0.67, which shows the performance of the heat exchanger and effectiveness is also vary according to the combination of velocity and inlet temperature of cold and hot fluid.



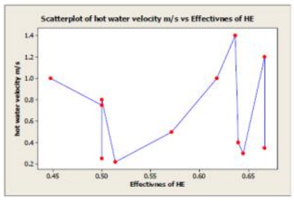
Experimentally Variations in LMTD with respect to hot water inlet velocity



Experimentally Variations in LMTD with respect to cold water inlet velocity



Experimentally Variations in Effectiveness with respect to cold water inlet velocity

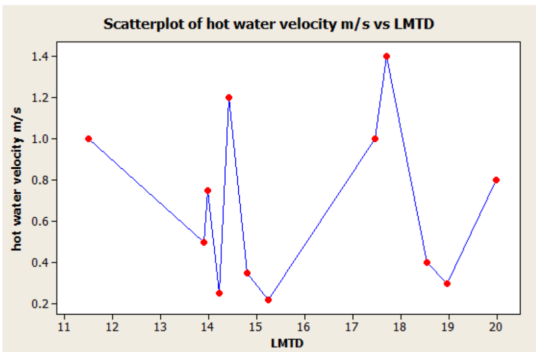


Experimentally Variations in Effectiveness with respect to cold water inlet velocity

Computational Fluid Dynamic Result of Shell and tube Type Exchanger

According to the experimental result we create the same combination of hot and cold fluid of the heat exchanger and perform each experiment in CFD workbench. There are 12 different separate combinations of inlet and out temperature of hot and cold fluid and different velocity. After the analysis of heat exchanger in CFD work bench we get set of output in the form of cold and hot outlet of both fluids.

The result obtained from the CFD workbench shows very good agreement between the outlet and inlet temperature of the hot and cold fluid as compare to the experimental result. Here the velocity and inlet temperature of cold and hot is same as the experimental and computed by on least square method. CFD work on ideal condition and no human as well as physical error like leakage, humidity etc considered, so its shown better result under the same boundary condition.



CFD Variations in LMTD with respect to hot water inlet velocity

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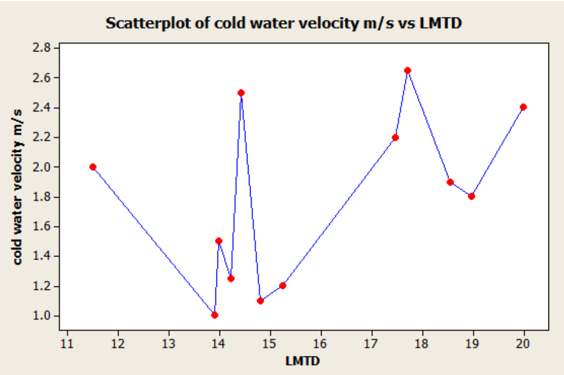
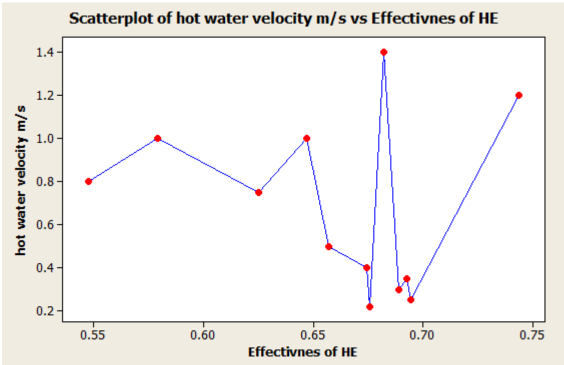
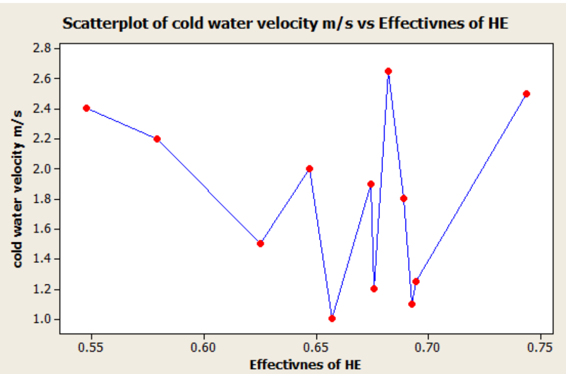


CFD Variations in LMTD with respect to cold water inlet velocity



CFD Variations in Effectiveness with respect to hot water inlet velocity

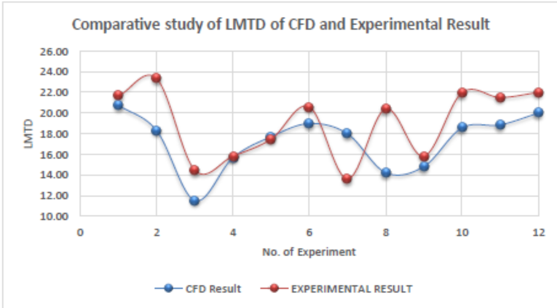


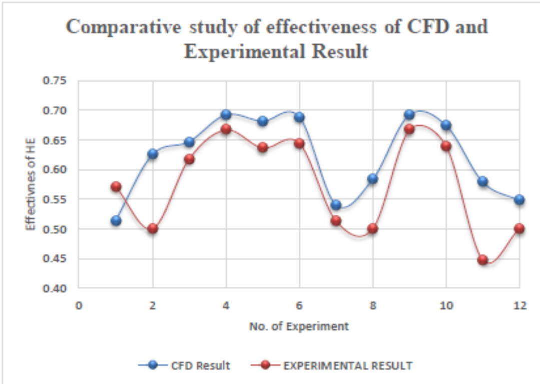
CFD Variations in Effectiveness with respect to cold water inlet velocity

VI. CONCLUSION & FUTURE SCOPE

Two different approaches have been performed to know the distribution of temperature and effectiveness of heat exchanger under the same working condition. The phase I we perform the experimental study in shell and tube type heat exchanger and taking 12 different combination of temperature and inlet velocity. Based on the output of experiment result we calculate the effectiveness and LMTD value for each experiment.

Similarly in phase II we are using the same combination of velocity and temperature of hot and cold fluid and performed the CFD analysis. A comparative graph of distribution of LMTD and effectiveness





the value of CFD and experimental result of heat exchanger and we found that the effectiveness of CFD result is higher than the experimental result except 1st experiment. The reason behind that is CFD workbench is work under the ideal condition and experimental study work on physical condition. The nature of graph is almost same for both the study and variation found during the experiment due to the change in velocity of fluid.

The experiment Number nine shows large value of effectiveness both cases while the experiment no 1st shows smallest value of effectiveness for both cases. Based on the analysis of the graph we concluded that the CFD result show better result as compare to the experimental result.

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