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Performance Studies On Shell And Tube Heat Exchanger Using Inserts

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Abstract
The present paper deals attempt with the design and simulation of a shell and tube heat exchanger (1, 2) in counter-flow arrangement. This project focuses the selection of different tube inserts, and makes comparison on the heat transfer coefficient for the two most common tube inserts: twisted tape and wire coil insert with and without baffles. In this research work, different fluids are used to study the characteristics regarding shell and tube heat exchanger. With respect to the quality of solution, it has been found that Simulation tool has a paramount position for the following areas of study in the heat exchangers such as unequal fluid flow, pressure drop ,turbulence of fluid ,temperature difference between two fluid ,thickness of material ,flow rate of fluid and thermal analysis in the design and optimization phase. A CFD (computational fluid dynamics) model HTRI has been used to predict the temperature distribution in steady-state conditions in shell and tube heat exchanger as well as fluid temperatures at exit of flow channels in transient condition. The simulated results obtained by the CFD model have been compared with the experimental data from the literature, which shows that the CFD model developed in this study is capable of predicting the steady-state and transient performance of the shell and tube heat exchangers satisfactorily. Various design modifications which are implemented and studied through simulation software or compared with experimental and numerically. Heat exchanger has a wide variety of engineering applications like Power generation, Waste heat recovery, etc….

Keywords: *Simulation, Heat Exchangers, Heat transfer coefficient, Inserts, Pressure drop*

1. Introduction

Heat Exchanger is a device which provides a flow of thermal energy between two or more fluids at different temperatures. Heat exchangers are used in a wide variety of engineering applications like power generation, waste heat recovery, manufacturing industry, air-conditioning, refrigeration, space applications, petrochemical industries etc. Shell and tube heat exchanger provide relatively large ratio of heat transfer area to volume and weight and they can be easily cleaned.

Shell and tube heat exchanger can be designed for high pressure relative to the environment and high pressure difference between the fluid streams. Shell and tube heat exchanger are built of round tubes mounted in a cylindrical shell with the tubes parallel to the shell. One fluid flow inside the tubes, while the other fluid flows across and along the axis of the exchanger, the major components of this exchanger are tubes (tube bundles), shell, front end head, rear end head, baffles and tube sheets.

We are concerned about the performance analysis of shell and tube type heat exchanger under different loading conditions. To do the same we have first designed a shell and tube type heat exchanger to get the dimensions of the parts involved and thereafter fabrication and testing of the actual working model has been done to see the effects of various parameters on the performance of the heat exchanger.

The need to increase the thermal performance of heat exchangers, thereby effecting energy, material & cost savings have led to development & use of many techniques termed as Heat transfer Enhancement. Heat exchangers are having both parallel and counter flow. In parallel flow both water and fluid are travelling in same direction but in counter flow water and fluid travel in opposite direction so it has long run utility. So we had chosen shell and tube heat exchanger in counter flow directions.

2. Experimental Setup

Fig shows the schematic diagram of the experimental setup. It is a shell and tube heat exchanger consisting of a calming section, test section, rotameters, overhead water tank for supplying cold water & a constant temperature bath (500 litre capacity) for supplying hot water with in-built heater,

pump & the control system. The test section is classified into two parts. Part one is called shell with dimensions of 51mm diameter and 500 mm length. Part two is called tube with the dimensions of 8 mm diameter and 500 mm length. Two calibrated rotameters, with the flow ranges 1 to 5 LPM are used to measure the flow of cold and hot water.

2.1 Specifications of Heat Exchanger

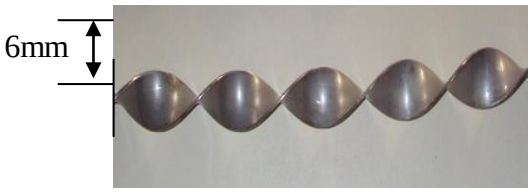
The experimental study is done in a shell and tube heat exchanger having the specifications as listed below:-

1	Material	SS 304
2	Shell Diameter	51 mm
3	Length	500 mm
4	Baffle material	Copper
5	Number of baffles	3
6	Number of Copper tubes	6

3. Types of Inserts

For experimentation, two types of inserts made from aluminium strips of thickness were used.

3.1 Twisted Tape:



3.2. Baffled Twisted Tape

4.1 Tables

Q Hot LPM	Q Cold LPM	U (W/m²k) water-water		
		Without inserts	With twisted tape	With baffled twisted tape
1	5	1142.69	1153.80	1183.0
2	5	1180.12	1190.80	1286.09
3	5	1200.69	1210.77	1386.90

4.2 Tables

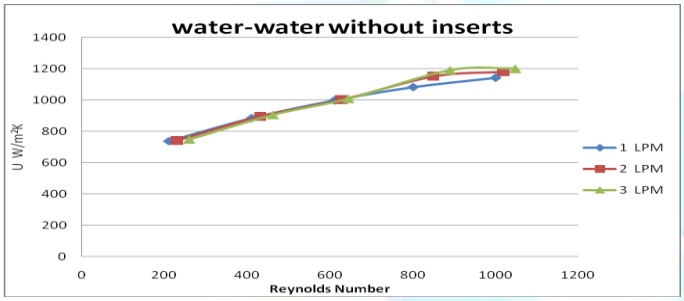
Q Hot LPM	Q Cold LPM	U (W/m²k) water-1 % Starch Solution		
		Without inserts	With twisted tape	With baffled twisted tape
1	5	642.16	691.34	732.68
2	5	703.32	801.16	861.15
3	5	813.49	858.14	893.42
4	5	889.75	932.73	981.81
5	5	932.19	1000.82	1042.00

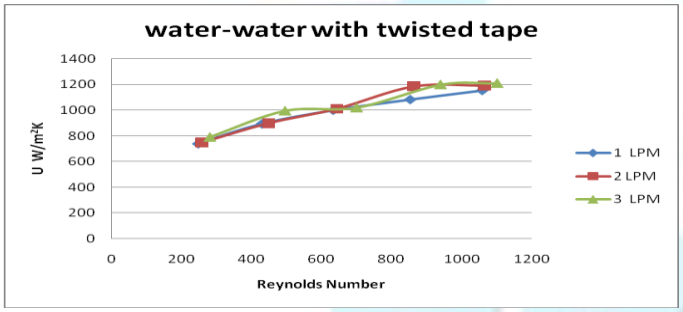
4.2 Tables

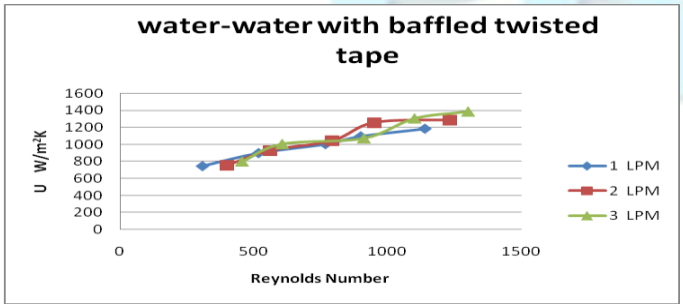
Q Hot LPM	Q Cold LPM	U (W/m²k) water-2 % Starch Solution

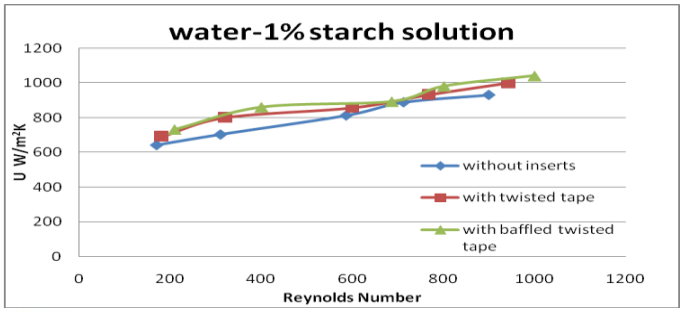
		Without inserts	With twisted tape	With baffled twisted tape
1	5	596.18	632.56	681.06
2	5	632.64	705.98	759.01
3	5	776.39	801.08	868.19
4	5	801.15	886.12	932.43
5	5	848.42	901.32	976.81

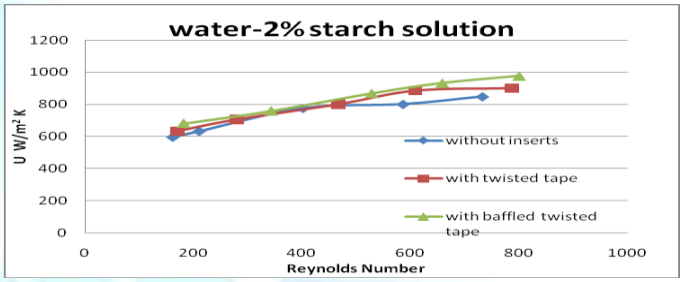
5. Graphs











6. Conclusions

This paper deals with the study of enhancement of heat transfer by using inserts in a shell and tube heat exchanger. Inserts such as twisted tape and baffled twisted tape are used. Heat exchanger characteristics like individual heat transfer coefficient and overall heat transfer coefficient are determined. Based on that comparison tables baffled twisted tape insert produced better heat transfer coefficient when compared to the twisted tape and plain tube. Starch solution offers more resistance to heat transfer because of suspended particles present in starch solution.

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