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INVESTIGATION OF HEAT TRANSFER ENHANCEMENT IN SHELL AND COIL HEAT EXCHANGER WITH BAFFLES USING COMPUTATIONAL FLUID DYNAMICS (CFD)

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Abstract - *Helical coil heat exchangers are widely used in industrial applications in power generation, chemical reactors, food processing because of its high heat transfer rate coefficient due to secondary flow. This paper focuses on heat transfer enhancement in helical coil heat exchanger with baffles. The shell and helical coil heat exchanger and its thermal analysis with counter flow configuration are to be done. This paper focuses on an increase in the efficiency of a heat exchanger by using the baffles so as to increase the heat transfer rate by increasing its turbulence and resident time. The thermal analysis is carried out considering the parameters such as flow rate of cold and hot water, temperature, effectiveness and overall heat transfer coefficient.CFD is tool used for analysis behavior of fluid flow. CFD tools have been extensively useful in the optimization of heat exchanger through the study of thermal performance, pressure drop, fouling and fluid mal-distribution . CFD analysis is carried out in ANSYS workbench.*

Key Words: Helical coil ,Heat Exchanger, CFD, Baffles.

1. INTRODUCTION

Heat exchanger is a device used to exchange heat between two fluids without mixing at different temperature. Two modes of heat transfer occurs in heat exchanger such as convection and conduction. Convection occurs in both working fluids and conduction through walls of heat exchanger which separates the fluids. Heat exchangers are used in a wide range of engineering applications, such as HVAC, aerospace industry and power generation. The main purpose of a heat exchanger is to efficiently transfer the heat from one fluid to the other. The performance of heat exchanger can be improved by improving the heat transfer between the heat exchanger fluids. There are so many ways to increase the heat transfer which include treated surfaces, rough surfaces, extended surfaces, surface vibration, and fluid vibration. The uses of baffles are recognized as one of the most effective means of increasing the heat transfer rate. The objective of this study was to investigate of enhancement in heat transfer rate with baffles using CFD . Experiments were conducted by keeping mass flow rate of water constant at different hot water temperature. Results were compared with CFD analysis. CFD is a modeling technique that breaks down the governing equations (continuity, momentum and energy) for fluid flow into simpler forms that can be solved using numerical techniques.CFD must then circumvent this by using models to approximate some components of the flow. This data acquiring from the different analysis is checked and choose the most effective way to increase heat transfer.

2. PROBLEM SETUP AND MODELING

In this study experimental as well as CFD analysis was done for investigation of heat transfer enhancement in shell and helical coil heat exchanger with and without baffles. For this purpose we arrange a experimental setup as shown in figure1. In this experimental setup there was two shell and coil one with baffles and another with without baffles. There was two water tank of cold and hot water.

Keeping the mass flow rate of hot water constant at different temperature of hot water such as $40^0{}_c$, $50^0{}_c$, $60^0{}_c$ and see their effect on heat transfer rate of helical coil with and without baffles. Modeling was done on CATIA software.

Figure 1 Experimental Setup

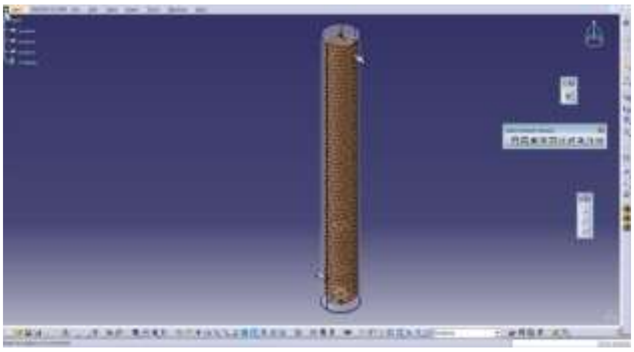

Figure 2 CATIA model of heat exchanger

3. SIMULATION AND FLUID FLOW

3.1 BOUNDARY CONDITIONS

Table 1 shows lists the boundary conditions applied at the inlet and the outlets of coil and shell.

Table -1: boundary conditions for CFX

Coil side inlet temperature (Th_i) (°C)	Shell side inlet temperature **(Tc_i)** (°C)
40	28
50	28
60	28

4. RESULT AND DISCUSSION

Table 2 shows the observations recorded during experimentation work of shell and coil heat exchanger with and without baffles. In this table gives the inlet and outlet temperature at 40°C,50°C, 60°C hot water inlet temperature in helical coil.

Table 2 Heat transfer rate of Shell and coil heat exchanger with and without baffles

Temperature of hot water in tank (°C)	Temperature of cold water in tank (°C)	Q_h with baffles (W)	Q_h without baffles(W)	Q_c with baffles (W)	Q_c without baffles (W)
40	28	18.95	15.37	13.05	6.41
50	28	45.70	41.60	41.85	34.31
60	28	80.24	66.07	76.5	51.18

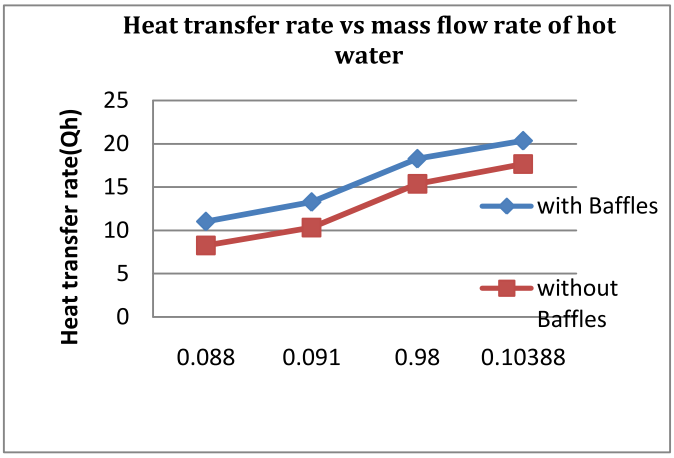

Chart -1: Heat transfer rate vs mass flow rate of hot water

Graph 1 shown above are of Mass flow rate of hot water versus Overall heat transfer. From this graph we seen that overall heat transfer rate is increasing of helical coil heat exchanger with baffles as compared to without baffles. This increase in overall heat transfer coefficient because of increase in turbulence and residential time due to baffles.

Table 3 Overall heat transfer coefficient (U_o)

U_o with baffles (w/m^2k)	U_o without baffles (w/m^2k)
208.76	202.42
308.64	300.10
406.50	390.47

4.1 CFD Results

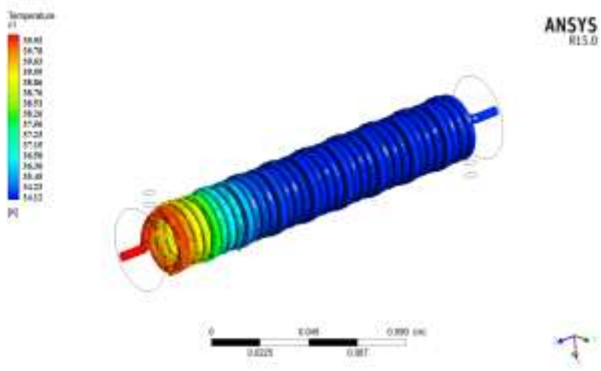

Figure 3. Temperature contour

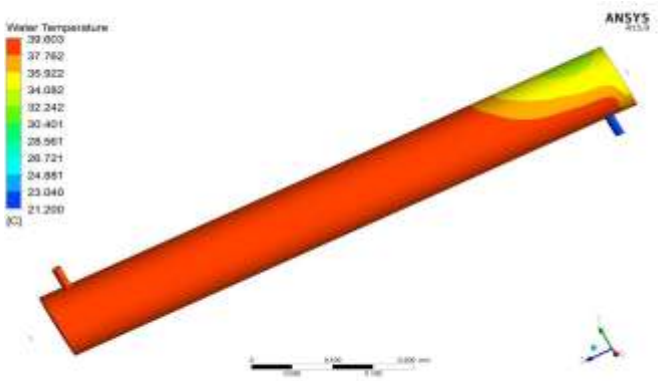

Figure 4: Temperature contour of water in shell

The temperature contour of shell side of the heat exchanger is shown in fig 4.13, the cold water enters in shell inlet of heat exchanger and gains heat as it approaches the shell outlet point. The water enters at Tc_i=21.20°C and leaves at Th_o= 39.60°C

Table 4 CFD result of pressure drop of helical coil heat exchanger with baffles

Experimental results outlet temperature (°C)	CFD results Outlet temperature (°C)	% Deviation
29	34.12	17.65
35	42.88	22.51
44	52.26	18.77

Table 5: Comparison between experimental and CFD results for without baffles

Experimental results Outlet temperature	CFD results Outlet temperature	% Deviation
23°C	26.8°C	16.52
30°C	35.65°C	18.83
42°C	48.06°C	14.42

3. CONCLUSIONS

The shell and coil heat exchanger are installed for the experimental study of heat transfer rate. Shell and coil heat exchanger is selected for heat transfer because of its advantages over other alternatives. Results regarding effect of various parameters on the heat transfer are plotted and through CFD methodology the heat transfer in shell and coil heat exchanger is studied. Conclusions drawn from the study are:

1. By using baffles in shell and coil heat exchanger we conclude that due to insertion overall heat transfer rate is increased.
2. The temperature and flow characteristics are captured reasonably by the CFD analysis. A close agreement is observed between the experimental and CFD results. The behavior of flow in the shell and coil heat exchanger was predicted and simulated in CFD. The outputs observed were compared with those recorded during experimentation and the deviation was observed to be between 10-20 %.
3. CFD analysis of heat exchanger helps in visualizing the volume fraction and temperature variation effectively which is difficult and uneconomical experimentally.

From above conclusion, we can say that by using baffles we can enhance the overall heat transfer rate.

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