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Effectiveness Improvement of Shell and Tube Type Heat Exchanger

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ABSTRACT: Generally, 35-40% of the heat exchangers used in industries are shell and tube heat exchanger. Here an experiment on shell and tube type heat exchanger is conducted. There are problems like scaling, fouling, welding defects and maintenance cost. In this experiment, design of shell and tube type heat exchanger baffle is changed. Considering this design as the basis, effectiveness of shell and tube type heat exchanger is measured. Performance in terms of effectiveness is firstly measured for normal flat baffle having 3:2 cutting ratio. Then performance in terms of effectiveness is measured for helical baffle. After measuring the performance for both types of baffle, results of both experiments are compared. Also the turbulence gained due to helical baffle helps to reduce the fouling effect in the heat exchanger.

KEY WORDS: Effectiveness, Helical Baffle, Heat Transfer rate, Turbulance.

I. INTRODUCTION

In this type of heat exchanger one of the fluids flows through a bundle of tubes enclosed by a shell. The other fluid is forced through the shell and it flows over the outside surface of the tubes. Such an arrangement is employed where reliability and heat transfer effectiveness are important.

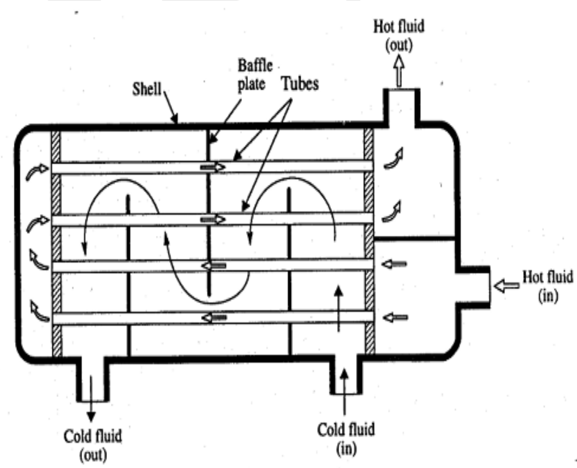

FIG: Shell and tube type heat exchanger

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II. CONSTRUCTION AND WORKING OF HEAT EXCHANGER AS PER DESIGN

As per dimensions a model of shell and tube type heat exchanger was fabricated. The fabricated model of shell and tube type heat exchanger is shown in the below figure.

FIG: Model of shell and tube type heat exchanger

Serial No.	Parameter	Dimension
1	Shell O.D.	90 mm
2	Shell I.D.	84 mm
3	Diameter of Tube holes	17 mm
4	Tube thickness	3 mm
5	No of tubes	7
6	Material of Tube	Copper

Table: Dimensions of shell and tube heat exchanger

III. CONSTRUCTION AS PER DESIGN

The heads are at the either side of the shell as shown in the figure assembly. Tube sheet is provided in between the shell and head in order to prevent leakage of either fluids and mixing of each other. It is having 7 holes for supporting the copper tubes and 8 holes for bolting. Copper tubes are enclosed inside the shell having inner diameter 84 mm and thickness 6 mm. The inner diameter and thickness of copper tubes are 13.9 mm and 1.5 mm respectively. One baffle is provided at one side of the center of the tube and another baffle is provided at the another side of the tube center at same distance (44 mm). The head, tube sheet and shell are connected with the help of bolt at both the sides. Champion sheet is provided for preventing the leakage of fluid between head and tube sheet as well as between tube sheet and shell.

Fabricated new helical baffle is shown in below figure.

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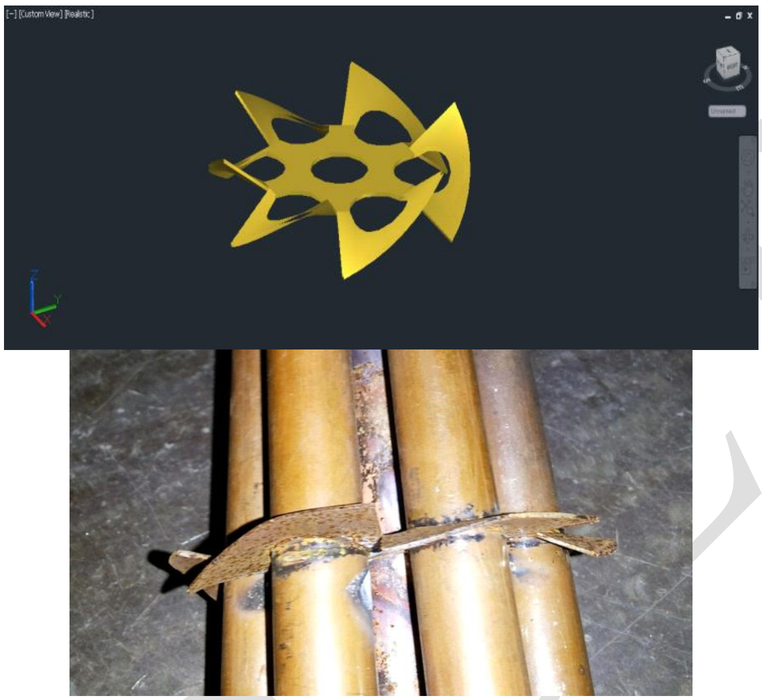

FIG: Helical baffle

IV. WORKING AS PER DESIGN

In this shell and tube type heat exchanger, both the fluids flow in opposite directions. The hot and cold fluids(water) enter at the opposite ends. The temperature difference between the two fluids remains more or less nearly constant. This type of heat exchanger, due to counter flow, gives maximum rate of heat transfer for a given surface area. Hence such heat exchangers are most favored for heating and cooling of fluids.

The hot fluid enters at a temperature of t_{h1} through the inlet head and after that it passes through the copper tubes which is having higher thermal conductivity. Because of higher thermal conductivity the heat transfer will occur effectively. After that the hot fluid having reduced temperature passes through the outlet head and exit the heat exchanger with temperature t_{h2}.

Cold fluid enters into the shell with temperature t_{c1} and it flows surrounding the copper tube inside the shell. Due to heat transfer between hot fluid and clod fluid the temperature of cold fluid gradually increases and after that the cold fluid exit the heat exchanger through the other side of the shell with a temperature of t_{c2}.

V. METHODOLOGY

At first complete set up of the Heat exchanger was done. Cold water inlet temperature is constant (15 ˚C) throughout the experiment. Only hot water inlet temperature is varied in the experiment. Firstly the whole experiment is conducted with flat baffle. Then complete experiment is done with helical baffle.

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VI. OBSERVATION TABLE

No.	Temperature For Flat Baffle (˚C)				Temperature For Helical Baffle (˚C)			
	T_{h1}	T_{c1}	T_{h2}	T_{c2}	T_{h1}	T_{c1}	T_{h2}	T_{c2}
1	44	15	42	18.2	44	15	40.8	20.1
2	46	15	43	19.8	46	15	41.7	21.84
3	51	15	47	21.4	51	15	44.9	24.7
4	60	15	54	24.5	60	15	50.5	30.11
5	65	15	57.6	26.8	65	15	54	32.5

Table: Observation Table

Various calculations are done as per following procedure.

- Calculate Heat Transfer Rate (Q , kJ/s) :-

  $Q = m\,C_p\,(T_{h1} - T_{h2}) = m\,C_p\,(T_{c2} - T_{c1})$

  Where, m = mass flow rate, kg/s
  C_p = specific heat of fluid at constant pressure, J/ kg ˚C
  T_{h1} = inlet temperature of hot fluid, ˚C
  T_{h2} = outlet temperature of hot fluid, ˚C
  T_{c1} = inlet temperature of cold fluid, ˚C
  T_{c2} = outlet temperature of cold fluid, ˚C

- Logarithmic Mean Temperature Difference (LMTD) :-

  $\theta_m = (\theta_1 - \theta_2) / \ln(\theta_1/ \theta_2)$

  Where, $\theta_1 = (T_{h1} - T_{h2})$,
  $\theta_2 = (T_{c2} - T_{c1})$

- Area of heat transfer (A, m^2) :-

  $A = n*2\pi rl$

  Where, n = Number of tubes,
  r = Radius of tube,
  l = Length of tube

- Overall heat transfer coefficient (U, W/m^2 ˚C) :-

  $U = Q / A\,\theta_m$

- Effectiveness (ε) :-

  $\varepsilon = C_h(T_{h1} - T_{h2}) / C_{min}(T_{h1} - T_{c1})$

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Where, $C_h = m_h C_{ph}$,

$C_c = m_c C_{pc}$,

C_{min}=minimum of C_h and C_c,

	Effectiveness for Flat Baffle (%)	Effectiveness for Helical Baffle (%)
1	10.97	17.55
2	15.39	22.06
3	17.67	26.95
4	21.21	33.58
5	23.54	35

Table : Effectiveness

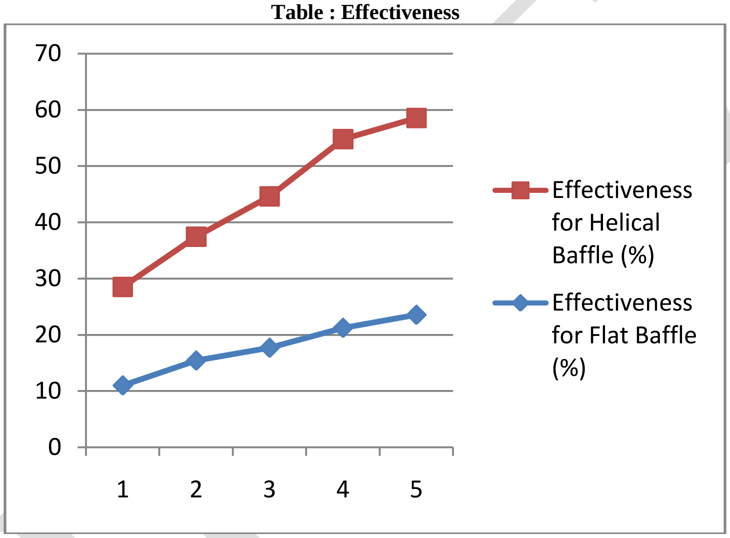

FIG: Diagram of effectiveness

VII. CONCLUSION

After performing an experiment, results of both baffles are compared. So, it is concluded that effectiveness of helical baffle is high compared to flat baffle for same inlet temperature of hot water and cold water.

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