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Increased Effectiveness of Shell and Tube Parallel Flow Heat Exchanger by Varying Viscosity Ratio Using CFD Simulation

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Abstract: ***In previous designs fins were present only on inner side of the heat exchangers. In this design fins are present on both the inner side and outer side of the heat exchangers. By this the staying time of the cold fluid and hot fluid is increased which increases the heat transfer rate. Temperature difference and Viscosity ratio are noted for various cold and hot inlet velocities. Investigation is carried out by increasing number of tubes inside hot fluid path and overall heat transfer rate is calculated. The parameter for which heat transfer rate is maximum is taken as the optimized design. The angle of inclination of the fins on both inner side and outer side are varied for the same cold and hot inlet velocities. In the place of vertical baffles, helical baffles are placed and the heat transfer analysis is carried out. Simulation process is carried out by increasing the number of tubes inside the hot fluid path and overall heat transfer is calculated. The design, for which the Viscosity ratio variation is maximum, can be taken as the optimized design for increased heat transfer rate.***

Keywords: H.I.V hot inlet velocity, CFD Computerized fluid dynamics

1. Introduction

Usually fins are present only on inner side of the shell and tube heat exchangers. Here fins are placed on both inner side and outer side of the heat exchanger. The inner fluid inlet rate and outer fluid inlet rate are changed at every stages and the effectiveness are calculated. The designing is done in ANSYS and CATIA. The purpose is to increase the viscosity ratio which increases the heat transfer rate. Here the performance analysis is also carried out for various designs by increasing the number of tubes and changing the types of baffles used (helical and vertical).

2. Background and History

In all the previous paper works analysis has been made on inner side of the heat exchangers. Also analysis has been done concentrating only on the heat transfer rate. Here the importance is given to the Viscosity ratio which is the main factor for increasing Heat transfer rate of the heat exchanger. No alterations has been done in the inlet velocities of hot and cold side.Un-baffled shell-and-tube heat exchanger design with respect to heat transfer coefficient and pressure drop is investigated by numerical modeling. Flow and temperature fields inside the shell and tubes are resolved using a commercial CFD package considering the plane symmetry [1]. The shell-side pressure drop of the LASH baffle heat exchanger is greatly decreased compared with that of the conventional segmental baffle heat exchanger [2]. Comparing with experiment data and heat transfer practical engineering correlations, it is shown that the model can be applied to simulate shell side characteristics of heat exchanger with longitudinal flow of shell side fluid, with higher velocity and reliability [3].

3. Design Parameters

Length of heat exchanger-1m
Diameter of hot fluid path- 10cm
Diameter of cold fluid path- 15cm

CIV m/s	HIV m/s
0.05	0.1
0.25	0.1
0.05	0.5
0.1	0.01

Velocities used for optimization process are as above.

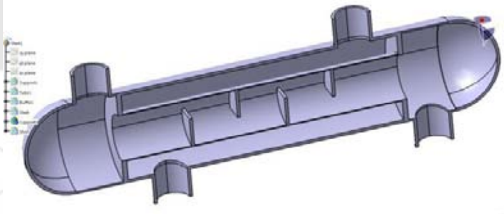

Figure 2.1

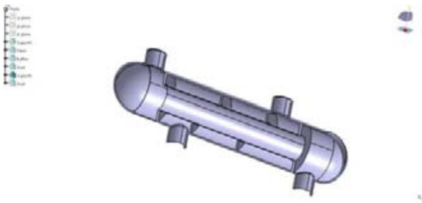

Figure 2.2

Figure 2.1 – baffles on inner side of the tube
Figure 2.2 – baffles on cold side pathFigure 2.3 – baffles present on both the side
Figure 2.4 – vertical baffles with increased number of tubes
Figure 2.5 – helical baffles with increased number of tubes

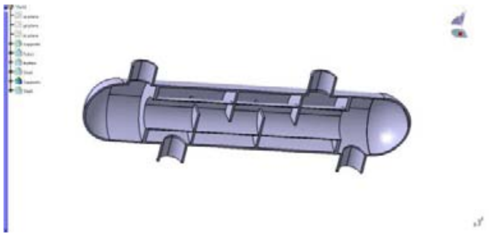

Figure 2.3

Figure 2.4

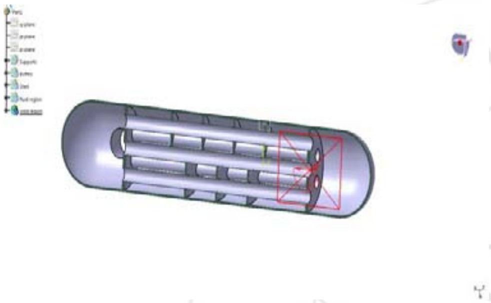

Figure 2.5

In computational modeling of turbulent flows, one common objective is to obtain a model that can predict quantities of interest, such as fluid velocity, for use in engineering designs of the system being modeled. **Computational fluid dynamics**, usually abbreviated as **CFD**, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows.

4. Methodology

Input parameters	• Cold side inlet velocity • Hot side inlet velocity • Cold side fluid inlet temperature • Hot side fluid inlet temperature
Output parameters	• Cold side fluid outlet velocity • Hot side outlet velocity • Cold and hot fluid side exit temperatures

Simulation process is carried out through ANSYS by varying the inlet velocities of cold and hot fluid. The design is for single pass with vertical baffles.

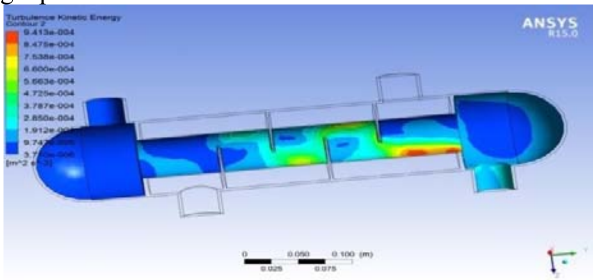

Figure 4.1

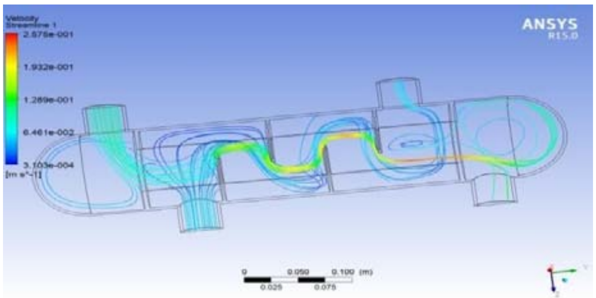

Figure 4.2

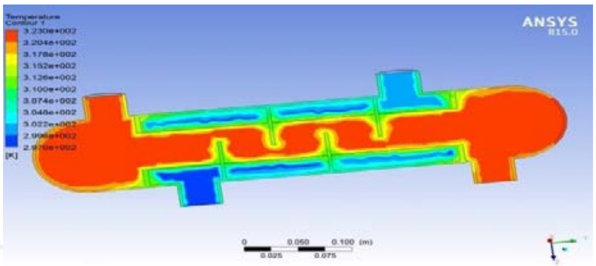

Figure 4.3

Figure 4.1- Viscosity ratio for CIV of 0.05& HIV of 0.1
Figure 4.2- velocity difference for CIV of 0.05& HIV of 0.1
Figure 4.3- temperature difference for CIV of 0.05& HIV of 0.1

Similarly, the inlet velocities of hot fluid and cold fluid are changed and the temperature difference, Viscosity ratio, velocity are noted. The velocity for which the heat transfer rate is maximum is taken as the common input parameter and is given for the multi-pass shell and tube heat exchanger for both vertical and helical baffles. The temperature difference, Viscosity ratio difference and velocity difference is also determined and is optimized. It has been made clear that for the CIV of 0.05 m/s and HIV of 0.5m/s the heat transfer rate is maximum.

5. Results and Discussion

Re= ꝭ v / μ
Where,
ꝭ - density of water (1000 kg/m^3),
v – velocity of water m/s,
μ - dynamic viscosity .
Nusselts number = hL / k
h- heat transfer rate
l- length of the heat exchanger
k- thermal conductivity of the material w/m^2k

For Internal flow
Nusselts number = 0.036 Re^0.8 Pr^0.33 (d/L)^0.055
Pr = Prandl number -5.540
K = 386 w/mk
Re value is taken from the inlet

Graphs for cold inlet velocity of 0.05 m/s and hot inlet of 0.5 m/s
Figure 5.1 length of heat exchanger vs. Viscosity ratio
Figure 5.2 length of heat exchanger vs. velocity
Figure 5.3 length of heat exchanger vs. temperature difference
Figure 5.4 Reynolds number vs. heat transfer at inlet

Figure 5.5 Reynolds number vs. heat transfer at outlet

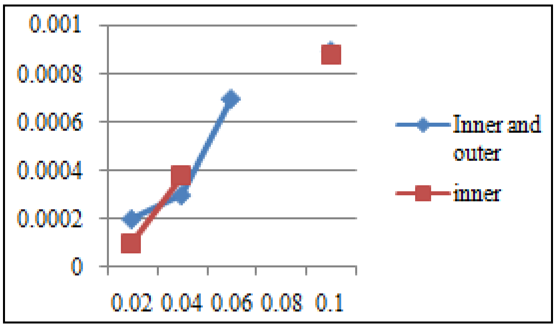

Figure 5.1

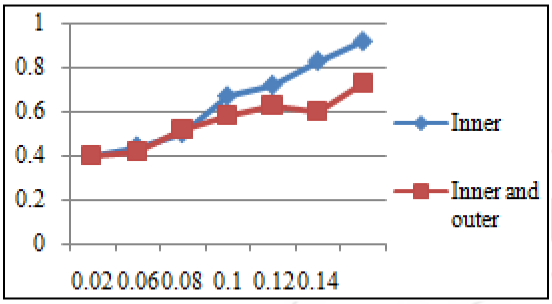

Figure 5.2

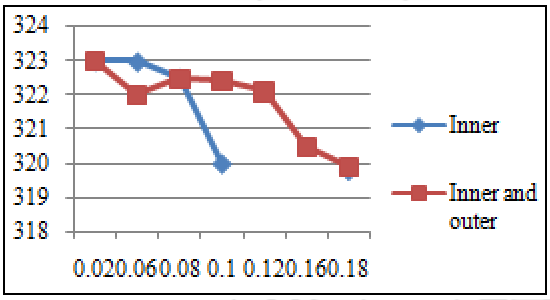

Figure 5.3

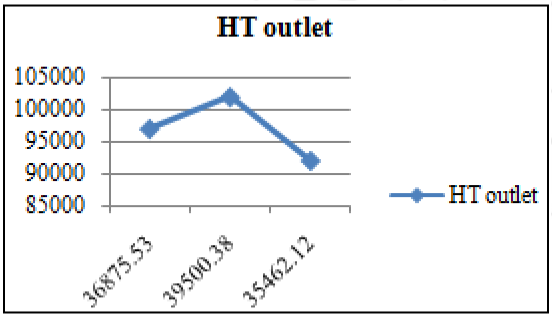

Figure 5.4

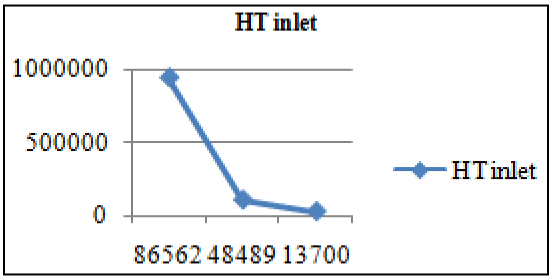

Figure 5.5

The inlet rate of the hot and cold inlets and also for the designs (single pass tubes and multi pass tubes, helical and vertical baffles) graphs are plotted and heat transfer rate is calculated.

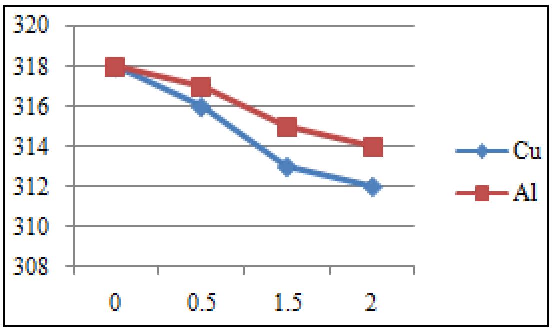

Figure 5.6: (CIV0.05& HIV 0.5 TD)-vertical

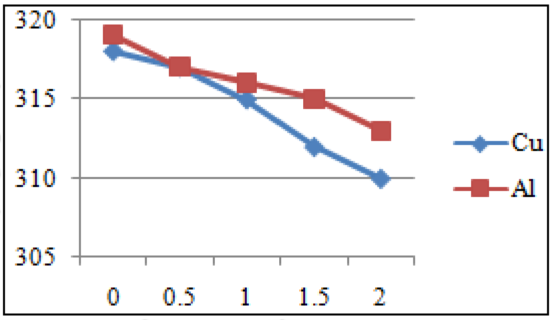

Figure 5.7: (CIV0.05& HIV 0.5 TD)-helical

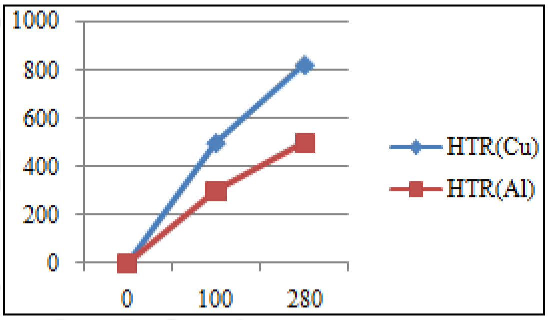

Figure 5.8: (CIV0.05& HIV 0.5 HTR)-helical

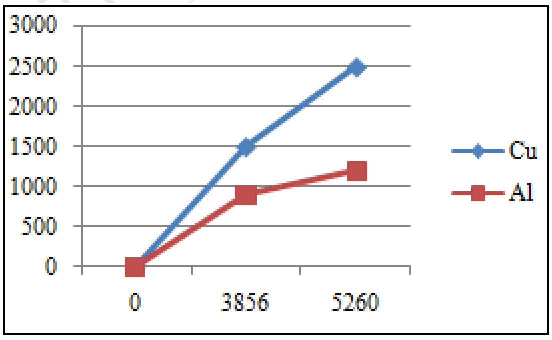

Figure 5.9: (CIV0.05& HIV 0.5 HTR)- vertically placed baffles multipass

6. Conclusion

The heat transfer rate is maximum in all the cases particularly for the fins present on both the sides of the heat exchanger. With respect to the changing of the cold inlet fluid rate to 0.5 m/s and hot inlet fluid rate to 0.05 m/s, the flow rate inside the hot side of the heat exchanger is decreased which simultaneously increases the staying periods of the fluid inside the heat exchanger. As known, the temperature difference is achieved consequently and the velocity is further increased (figure 5.2) but it is shown that Viscosity ratio increased in regions where inner and outer baffles are present and decreased in the remaining regions. Viscosity ratio of the model with baffles on the inner side is first decreased (figure 5.1) and is increased along the length of the heat exchanger. Also it is shown that, with increase in Reynolds number, the heat transfer rate is increased (figure 5.4). It has been found that, in all the cases, the temperature difference is maximum for copper due to its thermal conductivity (figure 5.6). Heat transfer rate is maximum for copper in helical baffles , compared to steel and aluminum. Similarly the heat transfer rate for copper in case of vertical baffles is also maximum (figure5.9).

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