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Numerical Investigation in a Single Phase Heat Exchanger by Varying the Turbulence Intensity

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Abstract—*Fins might be present either on the inner side or outer side of the heat exchanger. Here the fins are placed on inner side, outer side and both the sides of the tubes. The aim is to create the turbulence inside the heat exchanger which is the main factor for heat transfer. Heat transfer rate is analyzed through computational fluid dynamics for all the models. Temperature difference, velocity difference and turbulence intensity variation are taken for various cold inlet velocities of the fluid as well for various hot fluid velocities of the fluid. The angle of inclination of the fins on both inner side and outer side is 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 and design for which the turbulence intensity variation occurrence maximum is determined which can be taken as an optimized design for increased heat transfer rate.*

1. INTRODUCTION

Fins are present either on inner side of the baffle or on the outer side of the baffles, hereDuring the optimization process different cold inlet velocities and hot inlet velocities are given and checked out for the maximum heat transfer rate. The design and simulationprocess is done through ANSYS and CATIA. The main aim is to increase the turbulence which results in better heat transfer rate[8]. 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)[18].

2. BACKGROUND AND HISTORY

In all the previous works fins are placed either on the inner side or on the outer side of the tube. Also papers had not concentrated on the turbulence variation which is the main cause for the heat transfer process. The cold inlet and hot inlet velocities are kept constant as well. Here the inlet velocities are changed so that on which velocity maximum heat transfer rate achieved is determined. Un-baffled shell-and-tube heat exchanger design with respect to heat transfer coefficient and pressure drop is investigated by numerically 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-2m

Diameter of hot fluid path- 10cm

Diameter of cold fluid path- 20cm

Table 1: Velocity inlet and outlet

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.

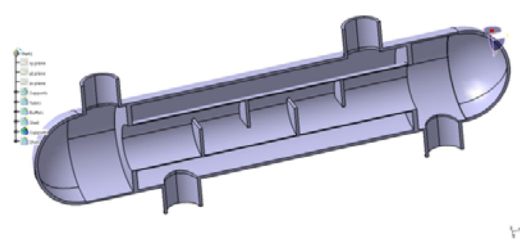

Fig. 1- baffles on inner side of the tube

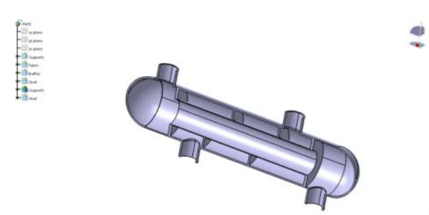

Fig. 2: baffles on cold side path

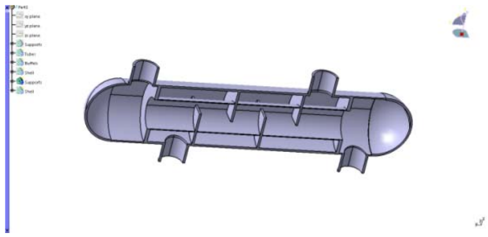

Fig. 3: baffles present on both the side

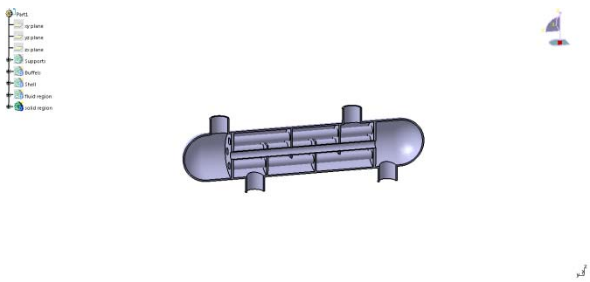

Fig. 4 : vertical baffles with increased number of tubes

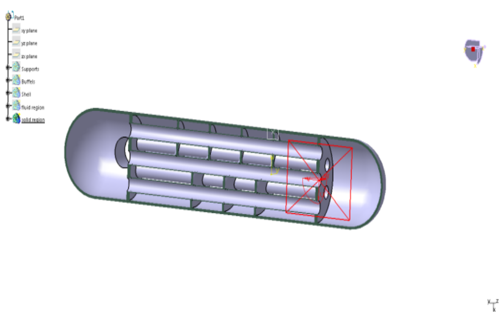

Fig. 5: helical baffles with increased number of tubes

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 numericalmethods and algorithms to solve and analyze problems that involve fluid flows.[9],[11]

4. METHODOLOGY

Input parameters	• Cold inlet velocity • hot inlet velocity • Cold fluid inlet temperature • Hot fluid inlet temperature
Output parameters	• Cold fluid outlet velocity • Hot outlet velocity • Cold and hot fluid 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.

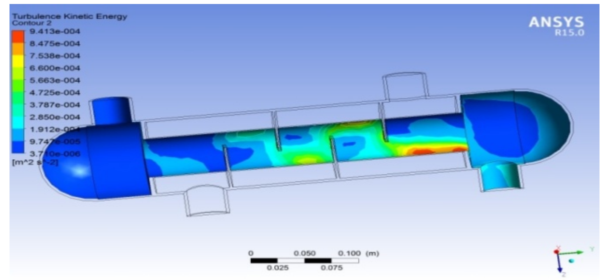

Fig. 6 : turbulence intensity for CIV of 0.05& HIV of 0.1

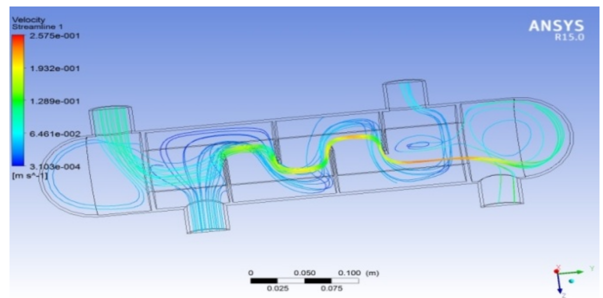

Fig. 7: Velocity difference for CIV of 0.05& HIV of 0.1

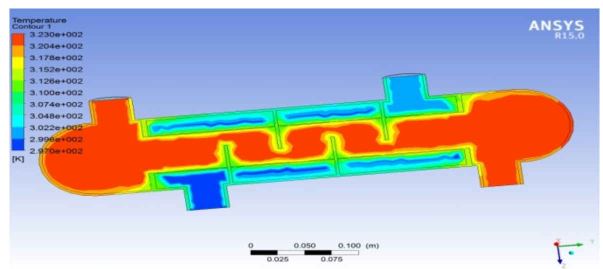

Fig. 8: Temperature difference for CIV of 0.05& HIV of 0.1

Similarly, the cold inlet velocities of hot fluid and cold fluid are changed and the temperature difference, turbulence intensity, 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 multipass shell and tube heat exchanger for both vertical and helical baffles. The temperature difference, turbulence intensity 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

$Re = \dot{\rho}\, v / \mu$

Where,

$\dot{\rho}$ - 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[9]

Graphs for cold inlet velocity of 0.05 m/s and hot inlet of 0.5 m/s

Graphs are plotted for length of heat exchanger ,turbulence intensity, temperature distribution and velocity difference.

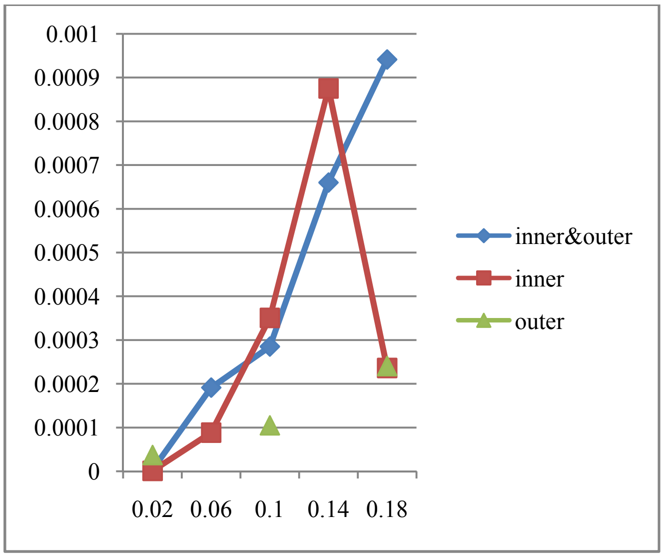

Fig. 9- length of heat exchanger vs. turbulence intensity

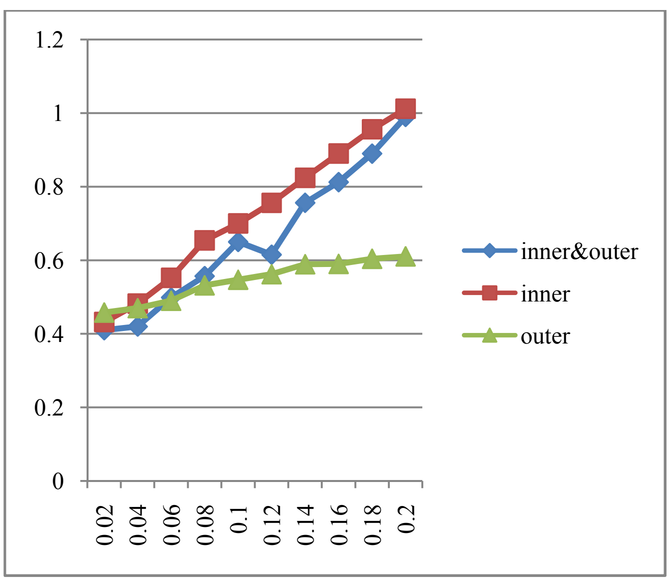

Fig. 10- length of heat exchanger vs. velocity

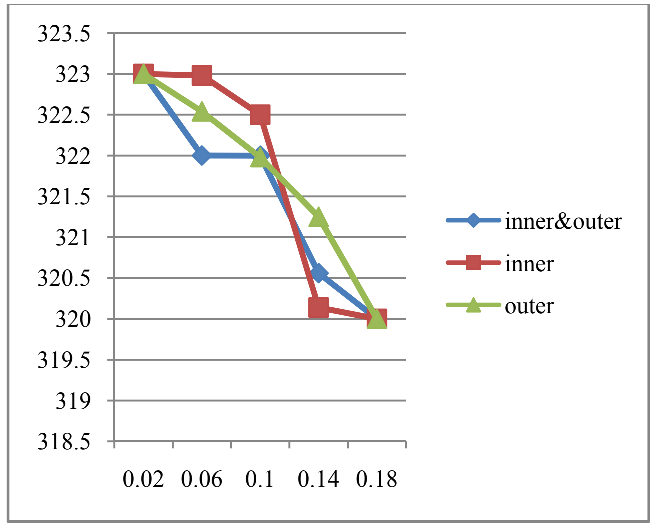

Fig. 11: length of heat exchanger vs. temperature difference

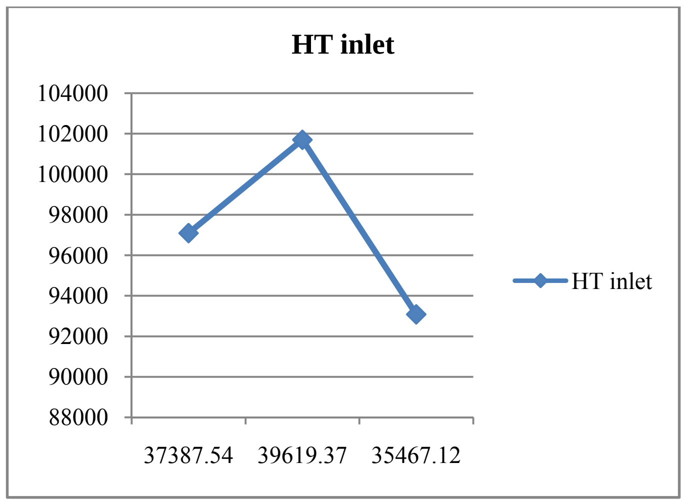

Fig. 12: Reynolds number vs. heat transfer at inlet

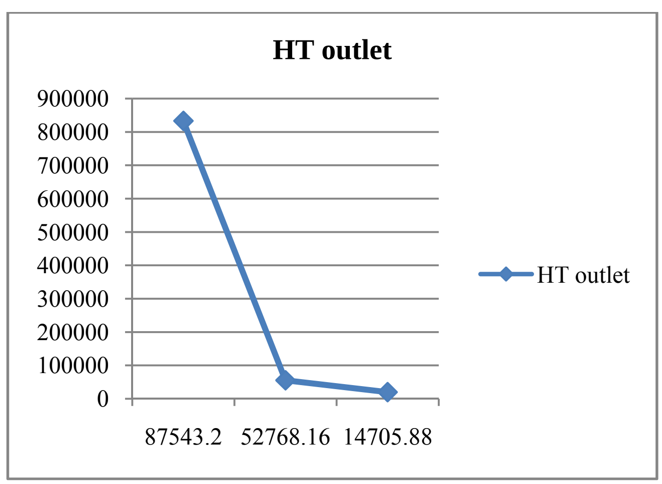

Fig. 13: Reynolds number vs. heat transfer at outlet

Similarly for all the inlet velocities (cold and hot) and for the designs (for single pas tubes and multi pass tubes also for helical and vertical baffles) graphs are plotted and heat transfer rate is calculated.

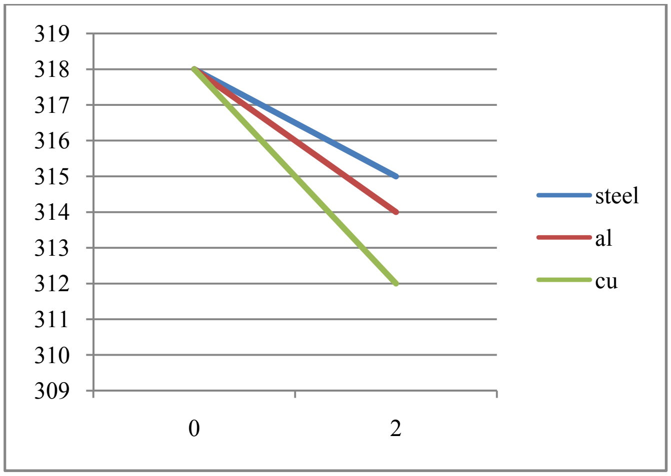

Fig. 14-(CIV0.05& HIV 0.5 TD)-vertical

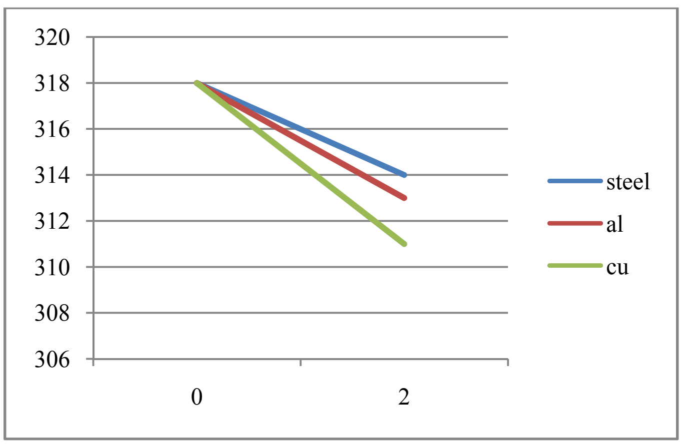

Fig. 15- (CIV0.05& HIV 0.5 TD)-helical

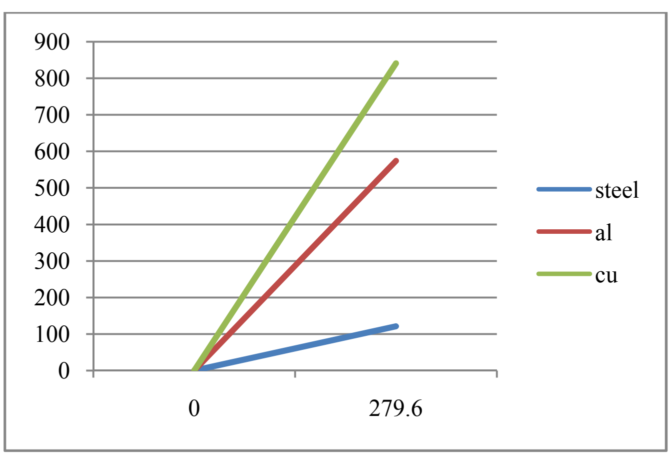

Fig. 16- (CIV0.05& HIV 0.5 HTR)-helical

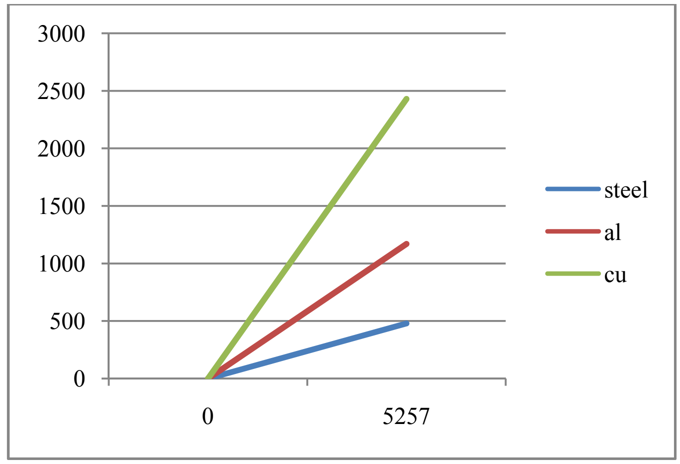

Fig. 17: (CIV0.05& HIV 0.5 HTR)-vertically placed baffles multipass

6. CONCLUSION

The turbulence is increased for all the cases (baffles on inner side, outer side, and both the sides). The flow rates is further changed to cold inlet velocity of 0.5m/s and hot inlet velocity of 0.05m/s with the aim as the flow rate of the hot fluid inside the heat exchanger is decreased the stay period is increased so the heat dissipated from the hot fluid is increased. As known the temperature difference is achieved consequently the velocity is further increased (Fig. 5.2) but it is shown that turbulence intensity inner and outer baffles present sides is alone is increased the remaining are decreased. Turbulence intensity of the model with baffles on inner side is first decreased (Fig. 5.1) and is increased along the length of the heat exchanger. Also shown with the increase in Reynolds number the heat transfer rate is increased (Fig. 5.4). it has been found for all the cases the temperature difference is maximum for copper due to its thermal conductivity(Fig. 5.6). heat transfer rate is maximum for copper in helical baffles when comparing with the steel and aluminum. Similarly the heat transfer rate for copper in case of vertical baffles is also maximum(figure5.9).

7. NOMENCLATURE

CIV- cold inlet velocity

HIV-hot inlet velocity

HTI- heat transfer at inlet

HTO-heat transfer at outlet

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