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Design of Six Step Dual Tube Heat Exchanger to Implement Cold Testing of PFHX

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ABSTRACT: *The present work in this dissertation clarified the design criteria of six step dual tube heat exchanger to implement cold testing of Plate Fin Heat Exchanger. The LMTD numerical method has been provided to estimate the length and number of tubes required for the Heat Exchanger and validate it with the CFD simulation which was carried out for batter improvement in the design to improve the potential of plate fin heat exchanger performance. This new type heat exchanger at the cryogenics temperature concept developed here for acquiring further research and then we will validate it with experiment data*
It was concluded that the six step heat exchanged was explained by two main factors one was a low pressure drop across inlet and outlet and the other was the high coefficient of performance and gives the result of six dual tubes is required for heat exchanger.

Keywords: *Plate, Fin, Heat, Exchanger, Nitrogen.*

I. INTRODUCTION

A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. The media may be separated by a solid wall to prevent mixing or they may be in direct contact The design of heat exchanger is this paper is at cryogenic temperature and the application of this heat exchanger will be used in cold test of plate fin heat exchanger. Since the application of plate fin heat exchanger widely spread in the cryogenics field because of its high efficiency and compactness. Here the heat exchanger functions at liquid nitrogen from room temperature to 80k. In this we presented numerical results of various parameters such as heat transfer coefficient, heat transfer rate, length etc. as a function of mass flow rate.

For the heat exchangers considered, there are several difficult design problems as outlined below. The heat exchangers use coils, which complicate performance predictions. Reliable data for thermo physical properties are often limited numbers and high temperature differences exceed the range of most correlations. Heat exchanger thermal design as discussed here is based on the heat transfer coefficients, the tube wall resistance combined to give the overall coefficient. Resistance is determined by the equation for heat flow through a cylinder. Heat transfer coefficients, related thermo physical properties, and other problems are discussed below.

II. TEST APPARATUS

The equipment shown in Figure 1 used for obtaining the outlet temperature at 80K that will connect to the plate fin heat exchanger for cold testing. Gaseous nitrogen (N_2) flow inside the tube and the tube will dip inside the liquid nitrogen Dewar using shell wall side boiling. Heating was achieved by using Gases nitrogen, on the tube side.LN_2 vaporizer stored in the tank is controlled by refilling it at a certain interval of time using supply line. Nitrogen flow was gradually increased with the length and temperature goes on decreasing with time respectively.

III. NUMERICAL MODEL

Inside tube heat transfer coefficients of gases nitrogen
For calculating Reynolds number mass flow rate of compressed fluid is 5.77 g/s

$$\therefore R_e = \frac{DG}{\mu} \text{.......................} (1)$$

Where $G = \frac{\dot{m}}{A} = \rho V$

If Re> 3500 flow is Turbulent [2] since in our case it is more than 3500

$$\therefore J_H = 0.023 \quad R_e^{-0.2} B_1 \text{..........................} (2)$$

$B_1 = 1$ for Gases

$$J_H = \frac{h_c P_r^{\frac{2}{3}}}{C_p G} ....(3)$$

From equation-3 we can calculate the heat transfer coefficients (h_c) of gaseous nitrogen inside tube.

Heat transfer coefficient from the tube wall to liquid nitrogen at 77k

Since the heat transfer is between tube wall and static fluid .So we will consider free convection

Therefore for free convection Nusselt number is given as [1]

$$Nu = 0.53(Gr\,\mathrm{Pr})^{1/4} ....(4)$$

$$Gr = \frac{D^3 g \beta \Delta T}{\nu^2} ....(5)$$

Where $Gr = \frac{D^3 g \beta \Delta T}{\nu^2}$ $Pr = \frac{\mu C_p}{K}$ $N_u = \frac{hD}{K}$ ....(5)

By equating 4 and 5 equations we will get the Heat transfer coefficient (h) from the tube wall to liquid nitrogen

Condensation outside Tube

For calculating Condensation outside Tube the convective contribution of heat transfer may be determined as follows [1]

$$N_u = 0.9428\left(\frac{R_{aco}}{J_{aL}}\right)^{\frac{1}{4}} ....(6)$$

The Nusselt number involves the properties of the vapour as

$$N_u = \frac{h_c D}{k} ....(7)$$

The $R_{ab}$is the film boiling Rayleigh number defined as

$$R_{aco} = \frac{g\rho_L(\rho_L - \rho_G)D^3\rho_{rL}}{(\mu_L)^2} ....(8)$$

And Jakob number also as

$$J_{aG} = \frac{C_L(T_{sat} - T_w)}{(i_{fg})_e} ....(9)$$

Where $(i_{fg})_e$ is an effective heat of vaporization

$$(i_{fg})_e = i_{fg} + 0.34C_L(T_{sat} - T_w) ....(10)$$

By equating 6 and 7 above equations we will get the Condensation outside Tube (hc)for liquid nitrogen.

For calculating over all heat transfer co-efficient,

$$\frac{1}{v} = \frac{1}{\left(\frac{r_0}{r_i}\right)\frac{1}{h_c} + \frac{r_0}{k}\ln\left(\frac{r_0}{r_i}\right) + \frac{1}{h_B}}$$

Where, r_0&r_i is outer & inner radius of tube

∴ Heat transfer rate

$$Q = UA(LMTD).........(a)$$

And also $Q = mc_v \Delta T.........(b)$

Equating (a) & (b) we get the length of the tube.

IV. RESULT

The numerical analysis represented in section 3 gives the calculated heat transfer coefficient of inside tube, on the shell wall and of the liquid nitrogen from their calculate the heat transfer rate and predict the length of the tube required. The CFD contour shows the result that the outlet temperature of 80K.

V. CONCLUSIONS

An extensive testing numerical and CFD simulation has been carried out with the purpose of establishing a six step dual tube heat exchanger to implement cold testing of plate fin heat exchanger for getting the outlet temperature of 80K. Liquid nitrogen boiling coefficients have been measured for a number of tubular heat exchangers. As a result of this testing, an analytical formulation for predicting boiling heat transfer rates in heat exchangers has been developed. This technique accounts for the mass velocity of the nitrogen flowing in the tubes, the geometrical considerations of each style of tube heat exchanger, and the effect of the tube wall temperature. This correlation has been shown to predict the flow outlet temperature.

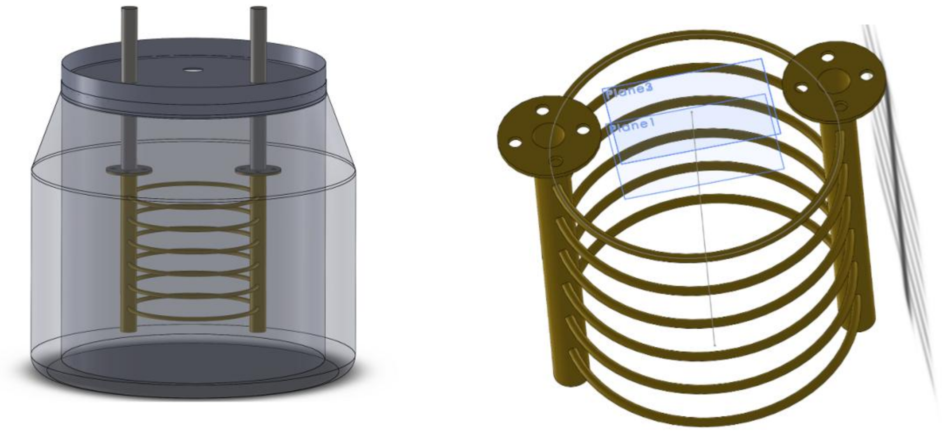
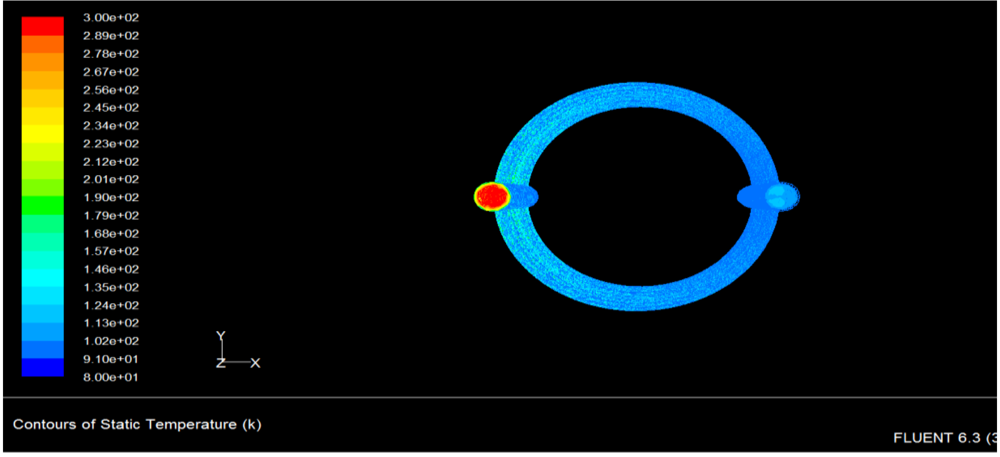


Figure 1



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