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DESIGN OF CUSTOMIZED HEAT EXCHANGER FOR OPTIMIZATION

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ABSTRACT

Heat exchangers are equipments used to transfer heat from hot fluid to cold fluid. These can be used as condensers as well as evaporators. The one proposed in the paper will be used as evaporator which is used as chiller in market. These chillers are used in various industries like printing press, food industries etc.. Currently, immersed type heat exchanger is used for the purpose which has issues due to its big size, frequent cleaning requirement. Here, designed heat exchanger is a customized shell and coil type heat exchanger as a replacement of this current system which will reduce overall size of the system which ultimately reduces the production cost. Also required chilling effect is obtained in lesser time.

Keywords: Immersed type Heat exchanger, Kern's method, shell and coil heat exchanger.

I. INTRODUCTION

Heat exchanger is a device which transfers heat from hot fluid to cold fluid. The current type of heat exchanger is immersed type of heat exchanger, in which, heat transfer takes place through natural convection. Heat transfer rate is less due to stagnant water. It requires more space causing wastage of usable area. It needs to be clean daily. We have designed shell and coil type of heat exchanger which transfers heat through forced convection also increases heat transfer rate as compare to immersed type. The proposed type of heat exchanger requires less space. It does not require to be cleaned on daily basis. It reduces running time for same result. Basically, this heat exchanger is said as customized because it is combination of helical coil heat exchanger and shell & tube heat exchanger. Kern's method for design of heat exchanger is used in designing this heat exchanger.

Fig. no. 1- Immersed type heat exchanger

II. PROPOSED DESIGN

A shell and coil heat exchanger can be used as condenser as well as evaporator. In this case it'll be used as evaporator. This heat exchanger will be used as chiller for chilling water which is further used for various applications in various industries. This chilled water is used in food industries, printing industries, textile industries etc

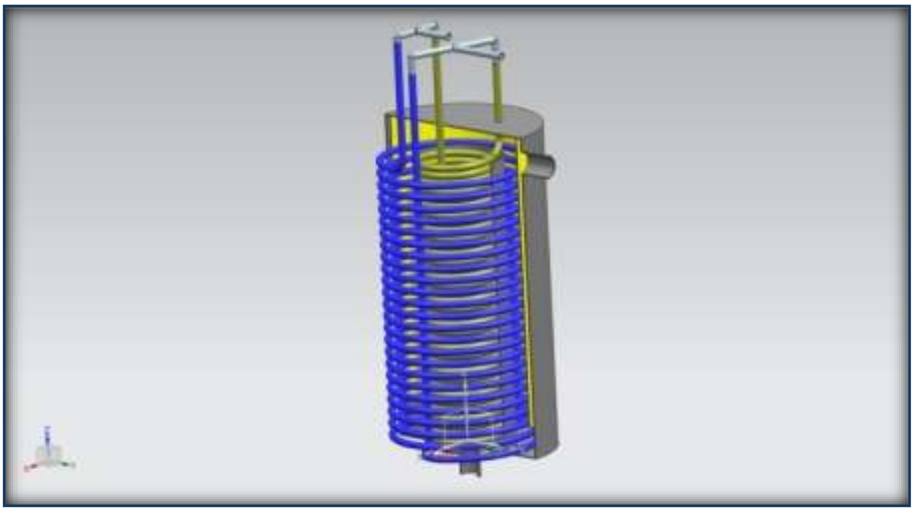

Fig. No. 2- Shell and coil heat exchanger

- **Construction:**

Basically it is a counter-flow heat exchanger. In the given approximate dimension constraints we have designed heat exchanger with 2 coils. We have provided partitions around the coils through which water flows. As water undergoes heat transfer 2 times in two different partitions, we can say that there are 2 single phase heat exchangers combined to get better refrigeration effect. Water first enters the inner cylinder from bottom which gets cooled due to inner coil, which further goes into the outer cylinder. And it finally goes from the outermost cylinder towards outlet. Here heat transfer takes place twice, hence we get better overall heat transfer rate.

III. DESIGN METHODOLOGY

Kern's method for designing heat exchanger consists of following steps:

Step 1: Collect physical properties and heat exchanger specifications.

In this step, we specify the physical properties and specifications required to fulfill by the heat exchanger.

Refrigerant - R 22

Water (Hot Fluid)

Capacity Required - 3 TR

Physical Properties:

Hot fluid (shell side)	Cold fluid (coil side)
$T_{hi}= 25^0C$	P_1=7.6 bar
$T_{ho}= 20^0C$	P_2= 18.6 bar
M_R= 0.5 kg/s	Latent heat of R22 = 237.763 KJ/kg

Step 2: Define heat duty and make energy balance

Using energy balance equation we calculate outlet temperature of water.

$$Mr \times \triangle h = Mw\ cp.\triangle T$$

Find out heat duty.

$$Q = Mw.\ Cp\ \ (T_1 - T_2)$$

Step 3: Calculate LMTD (Logarithmic Mean Temp. Difference)

$$\theta_m = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \frac{(T_1 - t_2)}{(T_2 - t_1)}}$$

Step 4: Assume overall Heat transfer coefficient.

For combination of R22 and water overall Heat transfer coefficient range is from 400 w/m^2K- 800 w/m^2K.[5]

Step 5: Calculate coil and shell dimensions.

Find out the surface area of coil.

$$Q = UA\,\theta_m$$

Now, to find out length of coil

$$A = \pi\, d_o\, L \qquad \text{.....}(d_o = \text{Tube dia.})$$

Calculate no. of turns of coil (N)

Height = (do) N+ (N-1) x Gap between two coils

Find out dia. of coil

$$d = \frac{\text{Total coil length}}{\pi N}$$

Step 6: Calculate Actual overall Heat transfer coefficient.

$$U_{actual} = \frac{1}{\frac{1}{h} + \frac{ri}{ro}\left[\frac{1}{ho}\right] + \frac{\ln\left[\frac{ro}{ri}\right]}{2\pi\, LK_{Material}}}$$

Find out heat transfer coefficient Of water

$$h_o = \frac{Nu\,K}{D}$$

Where,

$$N_u = 0.023\,(Re)^{0.8}\,(Pr)^{0.3} = \text{Nusselt number}$$

$$Re = \frac{\rho VD}{\mu} = \text{Reynold's number [1]}$$

$$P_r = \frac{\mu . Cp}{K} = \text{Prandalt number [1]}$$

Find out heat transfer coefficient of refrigerant (h_i) same as above procedure for water.

Using these values calculate actual overall heat transfer coefficient (U_{actual})

If the difference between U_{actual} and U_{assume} is < 30%, then design is acceptable. If not, assume another value of U within the specified range and do the calculation all over again.

Used formula for calculating partition diameter,

Partition diameter = coil diameter + 20 mm

IV.RESULT

After doing four iterations of $U_{assumed}$ within the specified range we calculated four U_{actual} for both, inner and outer coils. The iteration with least % difference can be selected i.e. dimension for that iteration can be said as optimum.

For inner coil :

Sr.No.	$U_{assumed}$ ($W/m^2 K$)	Coil Diameter (mm)	$U_{calculated}$	% difference
1	500	170	370.26	26.15
2	600	140	447.18	25.47
3	650	130	462.35	28.86
4	700	120	490	30

Selected value is – $U_{assumed}$ = 600 W/m^2K i.e. d_o = 140mm

Partition diameter= 140+20= 160mm

For outer coil :

Sr.No.	$U_{assumed}$	Diameter	$U_{calculated}$	% difference
1	550	285	426.25	22.5
2	600	260	474.01	21
3	650	240	505	22.30
4	700	225	561	23

Selected value- $U_{assumed}$= 600 W/m^2K i.e. diameter of coil =260

Partition diameter= 260+20= 280mm

V.CONCLUSION

Replacement of immersed type heat exchanger by this customized one will reduce the space required for the chilling system. From results it can be seen that, for a particular combination hot fluid and cold fluid combination number of heat exchanger with very similar heat transfer coefficients can be designed. Same chilling capacity will be achieved in lesser cost and size.

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