International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 10 | Oct -2017 www.irjet.net p-ISSN: 2395-0072

DESIGN OF HEAT EXCHANGER

James Edwin Prince Maikad[1], Alex Thomas[2], Fredy C Thomas[3], Gilbert C Thomas[4], Joseph John[5] Jithin K Kuriakose[6], Melvinraj C R[7]

[12345] UG Scholar, Dept of Mechanical Engg, Jyothi Engineering College, Cheruthuruthy, Kerala, Calicut University
[67]Asst. Professor, Dept of Mechanical Engg, Jyothi Engineering College, Cheruthuruthy, Kerala, Calicut University

---***---

Abstract - *A heat exchanger is a device used to transfer heat between a solid object and a fluid, or between two or more fluids. The fluids may be separated by solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical factories, petroleum refineries, sewage treatment, etc. The goal of heat exchanger design is to relate the inlet and outlet temperatures, the overall heat transfer coefficient, and the geometry of the heat exchanger, to the rate of heat transfer between the two fluids. Here we propose a design of a new heat exchanger and try to find the length of the tube required in it. The calculations are done by assuming suitable values for discharge and temperatures. LMTD method is adopted for the design process.*

Key Words: Heat exchanger, Shell and tube heat exchanger, LMTD method, Heat balance test, Counter flow, Length of pipe

1. INTRODUCTION

A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. In ordinary heat exchanger there is simple tubes are used. Ribbed tube heat exchangers make the use of internal ribs [1]. Our aim is to design a ribbed heat exchanger that provides more effectiveness. As the primary step we found the length of the pipe required. We did the calculations by assuming suitable values for discharge, diameters of the pipes and the inlet and outlet temperatures of both hot and cold fluids. The calculations are done by taking the flow of fluids as counter flow. This is because counter flow offers more effectiveness than parallel flow of fluids. Even though cross flow gives more effectiveness we rejected it as the design is too complex for the cross flow heat exchangers. Thus a design of a counter flow heat exchanger is performed.

2. PROBLEM STATEMENT

A heat exchanger is a device used to transfer heat between a solid object and a fluid or between two or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact [2].

The effectiveness of heat exchanger is a vital factor in the thermal industry. Heat exchangers that provide high effectiveness is of great demand today. In thermal problems, it is an important task to select a good combination of parameters level for achieving high effectiveness. Generally, this combination is hard to find.

Our aim is to design a heat ribbed heat exchanger. Here we are calculating the length of the pipe required for it. The following assumptions are made for the calculations. These assumptions are the input data for calculating the length of the pipe.

Type of flow – Counter flow
Diameter of inner pipe (hot fluid), D = 0.1m
Diameter of outer pipe (cold fluid), D_1 = 0.14m, D_2 = 0.15m
Discharge, Q = 40 liters/hour = 11.11kJ/s
Inlet temperature of hot water = 70°C
Outlet temperature of cold water = 37°C
Inlet temperature of cold water = 22°C
Outlet temperature of cold water = 35°C

3. CALCULATIONS

The calculation consists of computing the length of the pipe and heat transfer coefficient. From the heat transfer coefficient we obtain the length [3]. Allowing a reasonable fouling resistance a value of heat transfer coefficient is calculated from which the surface can be found with use of the Fourier equation: Q = U A Δt

3.1 Heat Balance Test

Cold Water = (22+35)/2 = 25°C
Specific heat of cold water = 4.17 kJ/kg°C
Mass flow rate of cold water = 1.24 kJ/s
Hot Water = (37+70)/2 = 53.5°C
Specific heat of hot water = 4.18 kJ/kg°C
W = (11.11)/(4.18 × (70-37))= 0.0699 kg/s
$W_{\text{hot water}}$ = 0.07 kg/s

3.2 LMTD (Assuming Counter Flow)

Hot		Cold
70°C	High Temperature	35°C (Δt_2)
37°C	Low Temperature	22°C (Δt_1)
	$\Delta t_2 - \Delta t_1$ = 10	

LMTD = $(\Delta t2-\Delta t1)/[2.3\log(\Delta t2/\Delta t1)]$
$=(35-15)/[2.3\log(32/15)] = 28.08$

A check of both streams will show that neither is viscous at cold terminal (the viscous less than 1 centipoise) and temperature ranges and temperature difference are moderate. The coefficient may accordingly be evaluated from properties at the arithmetic mean, and values of $(\mu/\mu_w)^{0.14}$ may be assumed to be equal to 1.

$T_{avg\ hot} = (37 + 70)/2 = 53.5^oC$
$T_{avg\ cold} = (22 + 35)/2 = 28.5^oC$
Flow area of inner pipe is greater than that of the annulus.

3.3 Measuring The Flow Area

Calculation for the hot fluid flow through the inner pipe.
D = 0.1m
Area, a = $(\pi D^2)/4 = (\pi\times 0.1^2)/4 = 0.00785\ m^2$
Maximum velocity, $G_A = (W/a) = (0.747/0.00785)$
$= 105.15\ kg/m^2 s$

Obtained μ at $T_{avg\ hot}$ depending upon which flow through the inner pipe.
μ in kg/ms = centipoise × 2.42

From D, G_A, μ we obtain Reynold's number as Re = $(D\times G_A)/\mu$
At 53.5^oC, centipoise = 2.42
μ = 0.41 × 2.42 = 0.0004102 kg/ms

Reynolds's number, Re = $(D\times G_A)/\mu$
= (0.1 × 105.15)/0.0004102= 25633.84
From the figure we get j_H = 207

From c, μ and k all obtained at $T_{avg\ hot}$, compute $(C\mu/k)^{1/3}$
C = 4.18 kJ/kg^{o}C
K = 0.6397
So $(C\mu/k)^{1/3}$= (4.18×0.0004102)/0.6397= 1.39

To obtain h_i multiply j_H by (K/D)× $(C\mu/k)^{1/3}$
h_i = (207×1.39×0.6397)/0.1= 1840 kJ/m^2^{o}C

Calculation of cold liquid flow through the annulus.
$D_1 = 0.14m$ $D_2 = 0.15m$
$a_0 = \pi (D_2^2 - D_1^2) / 4 = \pi (0.15^2 - 0.14^2) /4 = 0.00228\ m^2$

Equivalent diameter; $Dc = (D_2^2 - D_1^2) / D_1$
$= (0.15^2 - 0.14^2) / 0.14$
$= 0.0207$ m

Maximum velocity, $G_a = (W/a) = (1.24/0.00228)$
= 543.86 kg/m^{3}s

Obtained μ at $T_{avg\ cold}$ depending upon which flow through the inner pipe.
μ in kg/ms = centipoise × 2.42

From D, G_a, μ we obtain Reynold's number as Re =$(D\times G_A)/\mu$
At 28.5^oC, Centipoise = 0.85
μ = 0.5× 0.85 = 0.0001757 kg/ms
Re = $(D\times G_A)/\mu$ = (0.0207×543.86)/0.0001757 = 64074.7
From the figure we get j_H = 207

From c, μ and k all obtained at $T_{avg\ cold}$, compute $(C\mu/k)^{1/3}$
C = 4.17 kJ/kg^{o}C
K = 0.6129
So $(C\mu/k)^{1/3} = [(4.17\times0.0001757)/0.6129]^{1/3} = 1.06$

To obtain ho multiply j_H by (K/D)× $(C\mu/k)^{1/3}$
ho = (207×1.06×0.6129)/0.0207 = 4833.32 kJ/m^2^{o}C

Convert hi to hio ;

hio = hi×(Ai/A)= hi × (ID/OD)= hi × (Inner Diameter/Outer Diameter)
hio = 1840 × (0.1/0.14)= 1314.29 kJ/m^2^{o}C

Clear overall coefficient, Uc;
Uc = (hio × ho)/(hio + ho)
= (1314.29 × 4833.32)/(1314.29 + 4833.32)
= 1033.31 kJ/m^2^{o}C

Design overall coefficient, U_D;
$(1/U_D) = (1/Uc) + Ra$
$= (1/1033.31) + 0.002$
U_D = 336.31 kJ/m^2^{o}C

3.4 Required Surface

$Q = U_D \times A \times \Delta t$
A = $(11.11\times10^3)/(336.31\times28.08)$= 1.176 m^2
A = 1.176 m^2 = 3.76 ft^2
We choose 6 inch pipe.
6 inch = 1.734 ft^2

3.5 Length Of Pipe

Length of pipe = (3.76/1.734)= 2.17 ft
2.17 ft = 0.649 m
Length of pipe = 64.9 cm = 65cm

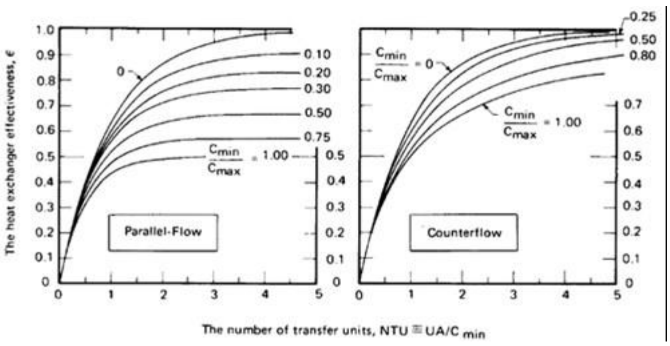

Chart -1: Comparison of effectiveness of parallel and counter flows

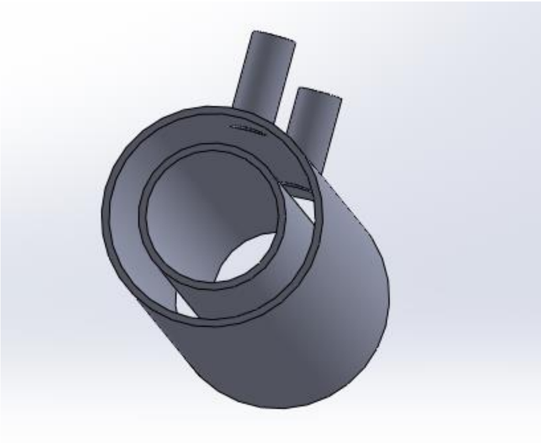

Fig -1: A model using SOLIDWORKS

3. CONCLUSIONS

On the basis of above study it is clear that a lot of factors affect the performance of the heat exchanger and the optimization obtained by the formulas depicts the cumulative effect of all the factors over the performance of the heat exchanger. It is observed that by changing the value of one variable the by keeping the rest variable as constant we can obtain the different results. Based on that result we can optimize the design of the shell and tube type heat exchanger. Higher the thermal conductivity of the tube metallurgy higher the heat transfer rate will be achieved. In double pipe heat exchanger we use counter flow heat exchange and as a result we acquired a higher rate of heat transfer.

The main conclusion after performing the design calculations is that the length of the pipe of the heat exchanger is to be 65 cm.

ACKNOWLEDGEMENT

We thank Mr. Jithin K Kuriakose and Mr. Melvinraj C.R , Assistant Professors of Mechanical Engineering Department of Jyothi Engineering College Cheruthuruthy for their support and guidance. We are also thankful to the Mechanical Engineering Department of Jyothi Engineering College Cheruthuruthy for all the help and suggestions.

REFERENCES

[1] Melvinraj C R, Vishal Varghese C & Vicky Wilson; Comparative Study of Heat Exchangers Using CFD; Int. Journal of Engineering Research and Applications; ISSN: 2248-9622, Vol. 4, Issue 5 (Version 4), May 2014

[2] Sadik Kakaç; Hongtan Liu (2002). Heat Exchangers: Selection, Rating and Thermal Design (2nd ed.). CRC Press. *ISBN 0-8493-0902-6*.

[3] Process Heat Transfer by Donald Q Kern, Professional Lecturer in Chemical Engineering Case Institute of Technology; Tata McGrawhills Publications pp. 110-115