International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 04, April – 2017, PP – 35-39

Design and Fabrication of Shell and Tube Heat Exchanger

M. Mani Bharathi, Shams Hari Prasad Mohan, Santhosh Sivan.M, Karthikeyan.S
Mr. M.D.Rajkamal M.E, (Assistant Professor)
Department of Mechanical Engineering, Velammal Institute of Technology

Abstract : A Heat Exchanger is a equipment used for transferring heat from one medium to another. There is a wide application of coiled heat exchanger in the field of cryogenics and other industrial applications for its enhanced heat transfer characteristics and compact structure. Lots of researches are going on to improve the heat transfer rate of the heat exchanger. Here, we have fabricated the shell and tube heat exchanger with selecting the materials on the primary objective of enhancing the heat transfer effectiveness. We casted the tube in the spiral shape with the helical angle of 30˚.Then we intended to perform calculation on the heat transfer Effectiveness. We are intended to show the merits of spiral coiled heat exchanger to that of the conventional parallel type heat exchangers.
Keywords: Effectiveness, Heat transfer, Helical tube, turbulence, counter current

I. Introduction:

Heat Exchanger is a device which provides a flow of thermal energy between two or more fluids at different temperatures. Heat exchangers are used in a wide variety of engineering applications like power generation, waste heat recovery, manufacturing industry, air-conditioning, refrigeration, space applications, petrochemical industries etc. Heat exchanger may be classified according to the following main criteria.

1. Recuperators and Regenerators.
2. Transfer process: Direct contact and Indirect contact.
3. Geometry of construction: tubes, plates and extended surfaces.
4. Heat transfer mechanisms: single phase and two phase.
5. Flow arrangements: parallel, counter and cross flows.

large ratio of heat transfer area to volume is provided by the shell and tube heat exchanger and weight and they can be easily cleaned. Great flexibility is always provided by the shell and tube heat excahngers to meet almost any service requirement. Shell and tube heat exchanger can be designed for high pressure relative to the environment and high pressure difference between the fluid streams.

II. Literature Survey:

A wide range of researches are already done to study the flow characteristics and heat transfer in helical heat exchangers. The enhancement of the heat transfer in the helically coiled tubes is due to the centrifugal forces. A secondary flow field is produced due to the curvature of the tube with a circulatory motion, which causes the fluid particles to move towards the core region of the tube..

Kevin M. Lunsford-1998

Kevin M. Lunsford evaluated the increasing heat exchanger performance through a logical series of steps. The first step considers if the exchanger is initially operating correctly. The second step considers increasing pressure drop if available in exchangers with single-phase heat transfer. Increased velocity results in higher heat transfer coefficients, which may be sufficient to improve performance. Next, a critical evaluation of the estimated fouling factors should be considered. Heat exchanger performance can be increased with periodic cleaning and less conservative fouling factors. Finally, for certain conditions, it may be feasible to consider enhanced heat transfer through the use of finned tubes, inserts, twisted tubes, or modified baffles. Most of these proprietary technologies can not be predicted a priori. However, combined with the enhancement information obtained from the vendors for specific cases along with estimations of heat transfer film coefficients, engineers can perform preliminary evaluations using these new technologies to increase shell-and-tube heat exchanger performance.

Durgesh Bhatt, Priyanka M Javhar-2012

Durgesh Bhatt, Priyanka M Javhar conducted a Shell and Tube Heat Exchanger Performance Analysis 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. Less is the baffle spacing , more is the shell side passes, higher the heat transfer but at the cost of the pressure drop.

JAY J. BHAVSAR, V K. MATAWALA-2013

The previous works carried out by different authors were limited to helical coil heat exchanger and spiral plate heat exchanger. The spiral tube heat exchanger is compact in size and more heat transfer can be carried out. The objective of present work is to streamline design methodology of spiral tube heat exchanger. The designed spiral tube heat exchanger is required to be developed and experiments will be performed on it to analyses pressure drop and temperature change in hot and cold fluid on shell side and tube side.

Vindhya Vasiny Prasad Dubey, Raj Rajat Verma-2014

Dubey and Verma conducted a Performance Analysis of Shell & Tube Type Heat Exchanger under the Effect of Varied Operating Conditions and concluded that It may be said that the insulation is a good tool to increase the rate of heat transfer if used properly well below the level of critical thickness. Amongst the used materials the cotton wool and the tape have given the best values of effectiveness. Moreover the effectiveness of the heat exchanger also depends upon the value of turbulence provided. However it is also seen that there does not exists direct relation between the turbulence and effectiveness and effectiveness attains its peak at some intermediate value. The ambient conditions for which the heat exchanger was tested do not show any significant effect over the heat exchanger's performance.

Dawit Bogale-2014

Dawit Bogale conducted a experiment on shell and tube heat exchangers showing optimization and redesign of the machine is done for both mechanical and thermal designs and the simulation for the heat transfer between the two fluid is analyzed using the concept of CFD (Computational Fluid Dynamics) using Gambit and Fluent software's. The final result of the STHEx in HBSC which is the redesigned STHEX can achieve or efficiently work to achieve the required outlet temperature 340˚C the temp at which the beer is ready for customer for use.

III. Methodology

Flow calculation Methodology:

Shell and tube heat exchangers are designed normally by using either Kern's method or Bell-Delaware method. Kern's method is mostly used for the preliminary design and provides conservative results whereas, the Bell-Delaware method is more accurate method and can provide detailed results. It can predict heat transfer coefficient with better accuracy. In this paper we have designed a simple counter flow shell and spiral tube type heat exchanger to cool the water from 85 to 55 by using water at room temperature by using Kern's method.

1. First we consider the energy balance to find out the values of some unknown temperature values. The energy balance equation may be given as:

   $$Q = m_1c_1(T_1-T_2) = m_2c_2(T_2-T_1)$$

2. Then we consider the LMTD expression to find its value:

LMTD or $\square T_m = (\Delta T1 - \Delta T2) / \ln(\Delta T1/\Delta T2)$

Where $\Delta T_1 = T_1-T_2$, $\Delta T_2 = T_2-T_1$

3. Then by using the amount of heat transfer formula we can get the heat transfer quantity:

   $$Q=UA(\square T_m)$$

4. Then we intended to find the Effectiveness of heat transfer by the following:

   $$\square = Q/(C_{min}*(T_1-t_1)$$

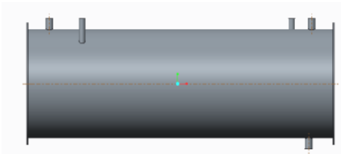
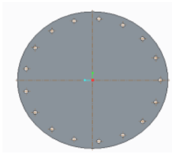
Design and fabrication Methodology: (Order)

1. Choosing the field of project.
2. Referring of research journals.
3. 2D&3D modeling with dimensioning.
4. Material selection and marketing.
5. Welding and machining processes.

6. Assembling.
7. Results and observations.

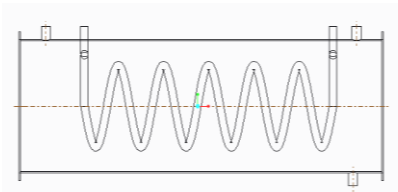
IV. Creo Model

We have used **Creo software** to design our model so that the possibility of error is reduced

V. Fabricated Model






VI. Components Required:

- Heater- 3L capacity
- Valves
- Hose pipes-5
- Shell
- Helical Tube
- Enclosures-2
- Containers-2
- Bolts and nuts-17
- Digital Thermometers-2

Material selection:

Shell Material: **Sheet Metal (MS)**

Sheet metal is thinner and flat. It's tougher and easy to weld. It has good electrical conductivity and less brittle and flexibility. Steel cools as it is rolled, with a typical rolling finish temperature of around 750°C.

Tube material: **Copper (Cu)**

Shape: Spiral type

Copper has good Thermal Conductivity and it is electrically conductive. It is corrosion resistance and has bio fouling resistance capability. It has good machinability and it can retend its mechanical and electrical properties at the cryogenic temperature. The **thermal conductivity** of copper is **385**W/mK.

VII. Fabrication:

Fabrication of this type heat exchanger was a challenging process and although we have stated our work as follows:

After the materials were purchased, as per the design parameters the dimensions on the materials have to make. Initially we marked the dimensions of the shell on the sheet metal. Then the sheet metal is cutted to that shape. It's then rolled into a cylindrical shape of diameter 200mm. To join the ends the TIG welding is done. The shell of the heat exchanger is ready to process. The copper tube which is of parallel type has to be folded to a helical shape which is considered to be tedious process. The spiral tube is placed by the supported enclosures on the both sides of the shell. The holes for inlet and outlet passage were also provided. The problems were faced in the bending of the spiral copper tube where the projections created due to improper bending may cause the blockage of water inside the tube. A heater is provided to raise the temperature of the hot water and a pump is provide to circulate the water inside the tube and it is also coupled into the cold water supply circulation.

VIII. Calculations

Design calculations:

Design of spiral tube:

Diameter of the inner tube $d_i = 10mm$
Diameter of the outer tube $d_o = 12.7mm$
Number of turns on the tube N= 6
Pitch of the spiral tube P= 45mm
Outside diameter of the coil D= 100mm

Design of Outer shell:

Thickness of the shell t = 1.2mm
Diameter of the shell d = 200mm
Length of the shell L = 600mm
Area of the shell= $\pi(r)^2 = \pi(100)^2 = 31.4\ mm^2$
Circumference of the shell
$= 2\pi r = 2*\pi*100 = 628mm$

Flow calculations:

Entry temperature of hot fluid T1=85°C
Entry temperature of hot fluid T2=55°C
Entry temperature of cold fluid t1=25°C
Exit temperature of cold fluid t2= 42°C
Specific heat of hot fluid c1=4180J/kg K
Specific heat of cold fluid c2=4180J/kg K
Overall heat transfer coefficient U=1600W/Km²

Design Calculations:

$T_1 = 85^0C$
$T_2 = 55^0C$
Heat transfer per kg of water in the shell is

$\mathbf{Q = mc_p(T_1 - T_2)}$
= (1)(4.18)(85-55)
Q = 209 J/Kg

We know that
Volume of the shell = volume of the water = **(□/4)*d² *L**

To find the mass of water in the shell we use the mass-density relation

Density(□) = Mass(m) / Volume(V)

$m = \rho*V$
$= 1000*(\pi/4) * (.2)^2 * (.6)$
= 1000 * 0.01884
m = 18.84 kg

Logarithmic Mean Temperature Difference (LMTD)

LMTD = (□T1 - □T2) / ln(□T1/ □T2)

= (85-40)-(55-25)/(In((85-40)/(55-25)))a

(□Tm) = 36.994 □C

Q = UA(□Tm)

Q = 1600*31.4* 36.994

Q = 3717.157 J (considering the time as 2 seconds)

Q = Quantity of heat transfer (W/m^2K)

To find the Effectiveness:

□ **= Q/(C_{min}*(T_1-t_1)**

= 3937.56/(18.84*4.18*60)

□ = 0.833

Where,

Q-heat transfer quantity (Watts)

□**T_m-**Logarithmic Mean Temperature difference (Celsius)

□-Effectiveness (no unit)

IX. Objective of Our Project

The use of spiral tube alternative to parallel tube increases the effectiveness by 10%.The fluid flowing through the tube will have to pass through an helix angle of 30˚through 6 turns and increases the fluid flow timing inside the shell which causes the heat transfer rate to increase because the cold water has enough time to absorb the heat from the hot fluid. Thus the heat transfer effectiveness is increased.

X. Conclusion:

Thus the experiment is conducted and the amount of heat transfer and the effectiveness of heat transfer is calculated. From our project we have shown that the spiral tube heat exchanger's effectiveness is more than the normal parallel flow heat exchanger.

XI. References:

[1]. K.S. Bharuka, D.Y. Kasture(1984), Flow through a helically coiled annulus, Applied Science Research, 41, 55–67.

[2]. Dawit Bogale(2014) , AJER, e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-10, pp-99-109 (Design and Development of Shell and Tube Heat Exchanger for Harar Brewery Company Pasteurizer Application (Mechanical and Thermal Design))

[3]. Durgesh Bhatt, Priyanka M Javhar,IJSR,ISSN(2011):23197064,researh paper on Shell and Tube Heat Exchanger Performance Analysis.

[4]. Kevin.L.Luthersford conducted a experiment to increase the heat exchanger performance It may be feasible to consider enhanced heat transfer through the use of finned tubes, inserts, twisted tubes, or modified baffles.(1998)

[5]. Ramesh K shah and Dusan P. Sekulic(2013), "Fundamental of heat exchanger design", Rochester Institute of Technology, Rochester New York.

[6]. Sandeep K. Patel, Professor Alkesh M. Mavani (2012)ISSN2249–8974IJAERS/Vol. II/ Issue I/130-135, Research Paper on Shell and tube heat exchanger thermal design with optimization of mass flow rate and baffle spacing.