To increase the efficiency of Heat exchanger

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[1,2,3,4,5,6,7,8] *LDRP-ITR*

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

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. Recuperates 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 exchangers 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.

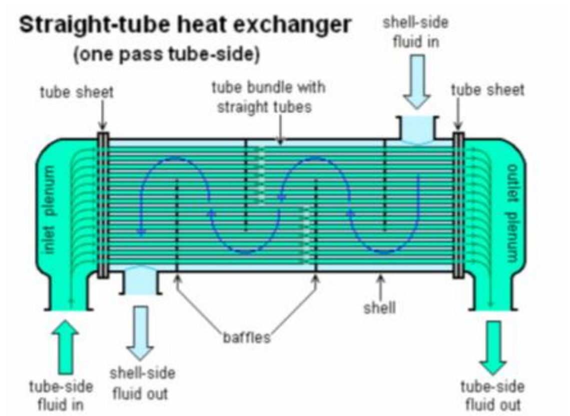


Fig -1: Shell and Tube heat exchanger

Baffle Design

Baffles are used in shell and tube heat exchangers to direct fluid across the tube bundle. They run perpendicularly to the shell and hold the bundle, preventing the tubes from sagging over a long length. They can also prevent the tubes from vibrating. The most common type of baffle is the segmental baffle. The semicircular segmental baffles are oriented at 180 degrees to the adjacent baffles forcing the fluid to flow upward and downwards between the tube bundles.

Baffle spacing is of large thermodynamic concern when designing shell and tube heat exchangers. Baffles must be spaced with consideration for the conversion of pressure drop and heat transfer. For thermo economic optimization it is suggested that the baffles be spaced no closer than 20% of the shell's inner diameter.

DESIGN AND ANALYSIS

Table -1: Design of Exchanger

S.No	Parameter	Dimension
1	Type of heat exchanger	1-1 pass shell and tube
2	Shell diameter	0.088m
3	Shell length	0.61m

4	Shell thickness	0.003m
5	Tube diameter	0.013m
6	Tube length	0.61m
7	Tube thickness	0.001m
8	Tube pitch	0.023m
9	Tube pitch type	Triangular pitch
10	Tube clearance	0.01m
11	Tube diameter ratio	1.08
12	Pitch ratio	1.76
13	Number of tube required	13 tubes
14	Number of baffle required	25 baffles
15	Baffle spacing	0.022m

Pitch type is taken as 60o triangular to utilize the baffle space effectively.

These design values and procedure are taken from the base paper "Heat transfer enhancement of shell and tube heat exchanger".

ANALYSIS PARAMETERS

Fluid: Water

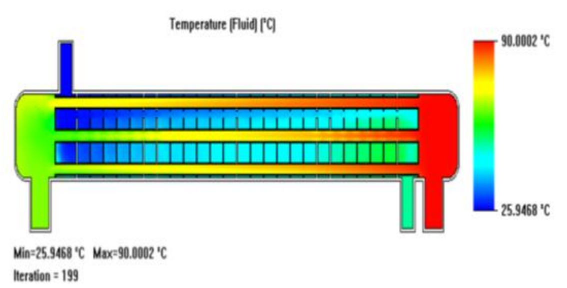
Heat Exchanger: - Material - Stainless steel 321, Counter flow shell & tube exchanger.

Initial temperature: Hot fluid = 90oC

Cold fluid = 26oC

Flow rate: Hot & Cold fluid = 0.0027 m3/s

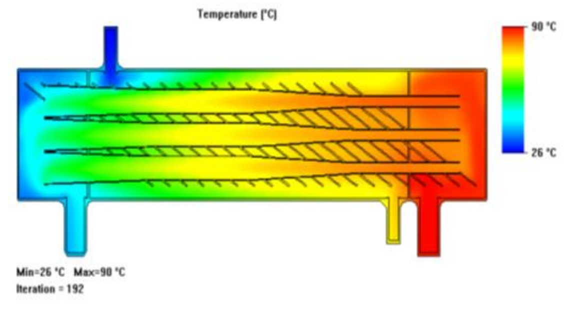
Environmental Condition: 27oC, 1 atm & heat transfer coefficient 5 W/m2K



Design of Heat exchanger

4S/4M Configuration

Analysis data



RESULT OF HEAT DISTRIBUTION

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 mach inability and it can retend its mechanical and electrical properties at the cryogenic temperature. The thermal conductivity of copper is 385W/mK.

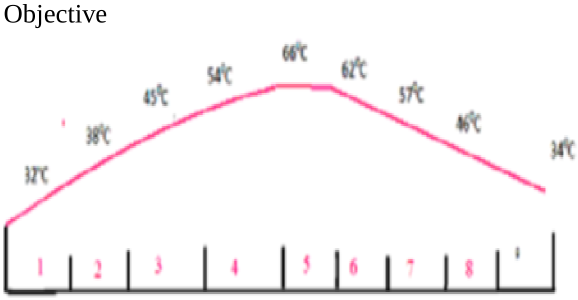
Fabrication:

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.

CALCULATIONS

Design calculations: Design of spiral tube: Diameter of the inner tube di = 10mm Diameter of the outer tube do= 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= π(r)2= π(100)2= 31.4 mm2 Circumference of the shell = $2\pi r$ = $2*\pi*100$ = 628mm Flow calculations: Entry temperature of hot fluid T1=85oC Entry temperature of hot fluid T2=55oC Entry temperature of cold fluid t1=25oC Exit temperature of cold fluid t2= 42oC 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: T1 = 850C T2 = 550C Heat transfer per kg of water in the shell is Q = mcp(T1 - T2) = (1)(4.18)(85-55) Q = 209 J/Kg We know that Volume of the shell = volume of the water = (Δ/4)*d2 *L To find the mass of water in the shell we use the mass-density relation Density(Δ) = Mass(m) / Volume(V) m = ρ*V = 1000*(π/4) * (.2)2 * (.6) = 1000 * 0.01884 m = 18.84 kg Logarithmic Mean Temperature Difference (LMTD) LMTD = (ΔT1 - ΔT2) / ln(ΔT1/ΔT2) = (85-40)-(55-25)/(In((85-40)/(55-25)))a (ΔTm) = 36.994ΔC
Q = UA(ΔTm) Q = 1600*31.4* 36.994 Q = 3717.157 J (considering the time as 2 seconds) Q = Quantity of heat transfer (W/m2K) To find the Effectiveness: Δ = Q/(Cmin*(T1-t1) = 3937.56/(18.84*4.18*60) Δ = 0.833 Where, Q-heat transfer quantity (Watts) ΔTm-Logarithmic Mean Temperature difference (Celsius) Δ-Effectiveness (no unit)

Objective



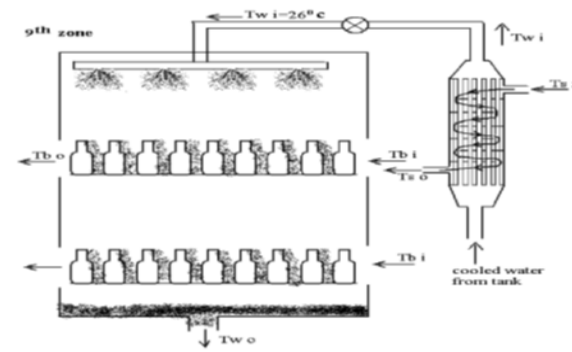


Figure1. Shows a) 9 Zone Temperature (0C) Vs. Time (min) b) 9th zone bottle pasteurized using STHEx9

METHODOLOGY

Design is an activity aimed at providing complete descriptions of an engineering system, part of a system, or just of a single system component design methodology for a heat exchanger as a component must be consistent with the life-cycle design of a system. There are two main design for this paper even for general design of STHEx 3.1. Thermal Design Heat exchanger thermal/hydraulic design procedures top in involve exchanger rating (quantitative heat transfer and pressure drop evaluation)and/or exchanger sizing. Only two important relationships constitute the entire thermal design. Two of the simplest (and most important) problems are referred to as the rating and sizing problems. 3.1.1. Rating Problem Determination of heat transfer and pressure drop performance of either an existing exchanger or an already sized exchanger (to check vendor's design) is referred to as a rating problem. Inputs to the rating problem are the heat exchanger construction, flow arrangement and overall dimensions, complete details on the materials and surface geometries on both sides, including their non-dimensional heat transfer and pressure drop characteristics (j or Nu and f vs. Re),{ fluid flow rates, inlet temperatures, and fouling factors. The fluid outlet temperatures, total heat transfer rate, and pressure drops on each side of the exchanger are then determined in the rating problem. The rating problem is also sometimes referred to as the performance or simulation problem. 3.1.2. Sizing Problem In a broad sense, the design of a new heat exchanger means the determination/selection of an exchanger construction type, flow arrangement, tube/plate and fin material, and the physical size of an exchanger to meet the specified heat transfer and pressure drops within all specified constraints. However, in a sizing problem for an extended surface exchanger, we will determine the physical size (length, width, height, and surface areas on each side) of an exchanger. For a STHEx a sizing problem in general refers to the determination of shell type, diameter and length, tube diameter and number, tube layout, pass arrangement, and so on. Inputs to the sizing problem are surface geometries (including their dimensionless heat transfer and pressure drop characteristics), fluid flow rates, inlet and outlet fluid temperatures, fouling factors, and pressure drops on each fluid side.

RESULTS AND DISCUSSION ANALYSIS AND DESIGN EQUATIONS OF STHEX

The beer from the 8th zone enters the 9th zone at 460C which is the desired temperature let us calculate the out let temperatures of the hot water in which it is going to be used to cool(decrease the final temperature) the beer for the final processing. Let us compute the mass flow rate of the beer in our zone. HBSC produce 90 million bottles of beer per year it works 6 days per week and 16 hours per day. so it works for(365-(13+4*12))/16=4864 hr\year the volume flow rate of the beer in this zone isVb=90e6*0.33/48640=6160.0855 lit/hr or Vb=6.1258kg/sec.

1.1. Determination Of hi

The mass flow of water (hot water comes out of HEx) is determined from (Mcp)beer=(Mcp)water Equation1 but the specific heat of 2.16 and that of water is 4.186 the percentage presence of alcohol is 4.25% and the rest is water. so that the specific heat of Harar beer is determined from Cpb=0.0425*2.16+0.9575*4.186=4100 J/kg`c Hence the mass flow rate of the water to this zone per second .

Mw=6kg/sec The heat lost from the beer during heat transfer process with the hot water in which the hot water absorbs heat. In the9th zone the total heat loss =301392W Equation2 To know the lost from one bottle beer the diameter at the base of the bottle is 6 cm so that the number of beer along the length and width of the 9th zone pasteurizer respectively is NobL=3/0.06=50 bottles Nobw=4/0.06=66.03 bottles The heat lost from one bottle = total heat lost/ total no of bottles=30139w/ 6600 =45.64 w The convective heat transfer coefficient for the beer if we take the 9th zone as one system and the heat film condensation take place on the vertical bottles of beer as in tubes the beer is at a saturation temperature of 460C and Assumptions-

- Steady operation condition exists
- The bottles of beer is isothermal
- The bottles considered as a cylinder

The convective heat transfer coefficient for the beer and the water is the same and also be the same properties each bottle are maintained at a surface temperature of 360C

Properties:-The properties of water at the saturation temperature of 460C are hfg=2393e3 J/kg ρv=0.069 kg/m The properties of liquid at the film temperature of =410CEquation3 The modified latent heat of vaporization Equation4 Hfg* Nothing that ρv<<<ρl(since 0.06<<<991) the heat transfer coefficient for a condensation on a single vertical (bottles) is determined and laminar film condensation takes place and the height of the bottle h=10.8cm Now let us compute the temp at which the hot water leaves the heat exchanger and sprayed on the beer. We know that the heat lost by the hot beer is equal to the conduction heat transfer along the thickness of the bottle and the convective heat transfer to the hot water.

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CONCLUSION

As all knows shell and tube heat exchanger are the most important devices in that installed to assist some plants and several industries like Harar Brewery Share Company but here the STHEx at the 9th zone was malfunctioned that is the temperature of the cold fluid would fluctuate between 350C-400C.Then some optimization and redesign of the machine is done for both mechanical and thermal designs and the simulation fo 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 340C the temp at which the beer is ready for customer for use.

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