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Research Article

Analysis of Segmental and Helical Baffle in Shell and tube Heat Exchanger

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Abstract

In this project work the analyze of two different baffle in a Shell and Tube Heat Exchanger done by ANSYS FLUENT. Shell and tube heat exchanger has been widely used in many industrial applications such as electric power generation, Refrigeration and Environmental Protection and Chemical Engineering. Baffle is an shell side Component of shell and tube heat exchanger The segmental baffle forces the liquid in a Zigzag flow and improving heat transfer and a high pressure drop and increase the fouling resistance and Helical Baffle have a Effective Performance of increasing heat transfer performance. The desirable features of heat exchanger obtain a maximum heat transfer Coefficient and a lower pressure drop. From the Numerical Experimentation result the performance of heat exchanger is increased in Helical Baffle instead of Segmental Baffle

Keywords: *Heat Transfer Coefficient, Helical Baffle, Segmental Baffle, Shell and Tube Heat Exchanger, FLUENT ANSYS.*

1. Introduction

A Heat Exchanger is a device used for efficient heat transfer from one fluid to other fluid a typical heat exchanger is shell and tube heat exchanger. They consist of series of finned tubes in which one of the fluid runs in the tube and the other fluid run over the tube to be heated or cooled During the heat exchanger operation high Pressure High temperature water or steam are flowing at high velocity inside the tube or plate system. Advantages of(1) configuration of Shell and Tube heat exchanger provide larger surface area with a small shape(2) This type of heat exchanger is good mechanical layout and good for pressurized operation.(3)Shell and Tube Heat Exchanger is Easy to clean (4) The shell and tube heat exchanger is made up of different type of materials in which selected materials is used for operating pressure and Temperature.

The Helical Baffle heat Exchanger is otherwise known as a Helix changer solution that removes many of the deficiencies of Segmental Baffle Heat Exchanger[3].It is very effective where heat exchanger are predicted to be faced with vibration condition Quadrant shaped baffle segment are arrange right angle to the tube axis in a sequential pattern that guide the shell side flow in a helical path over the tube bundle.the Helical flow provide the necessary characteristics to reduce flow dispersion and generate near plug flow conditions. The shell side flow configuration offers a very high conversion of pressure drop to heat transfer.

The major Drawback of shell and Tube Heat Exchanger first it cause a larger Pressure Drop secondly it result in a dead zone in each Component between 2 adjacent Baffles leading to an increase of Fouling Resistance and the Dramatic Zigzag flow cause a high risk of vibration failure on tube bundle [6].The Helical baffle depends on the helix angle which determines the Pressure drop on shell side. Segmental baffles in a heat exchanger have some limitations in a shell side flow path is wasteful cause a Excessive Pressure loss while recovering less heat transfer These type of arrangements of baffle limits maximum thermal effectiveness.

In this Project work The work done on the analysis of Segmental and Helical baffle in a heat exchanger and They shows the higher heat transfer and lower Pressure drop is achieved in a helical baffle compare to segmental baffle A virtual model of helical and segmental baffle was Created in a PRO E and analyzed in a FLUENT ANSYS Based on the performance of parameters such as Pressure Drop Heat Transfer Coefficient, Baffle spacing and pitch angle we choose the best one in Baffles.

2. Shell and Tube Heat Exchanger

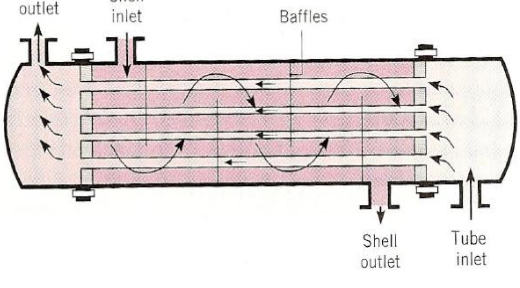

Fig.1 Geometry of Shell and Tube Heat Exchanger

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2.1 Experiment

The analysis of a 3D Model has been Performed by Using FLUENT ANSYS The Analysis carried out by using segmental and helical Baffle For analysis the input data is static for both type

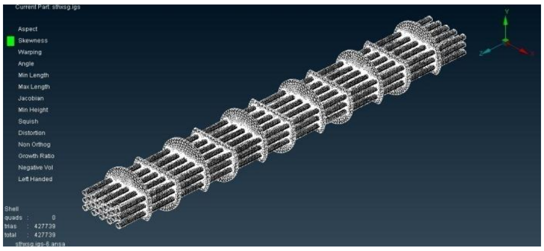


Fig. 2 Surface mesh with Tube and Shell in Segmental

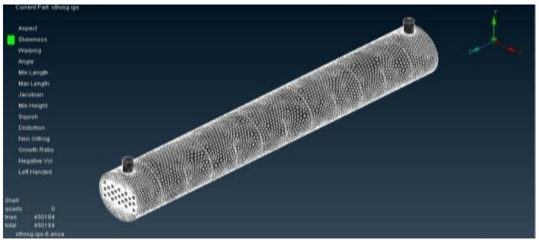


Fig. 3 Surface mesh with outer shell

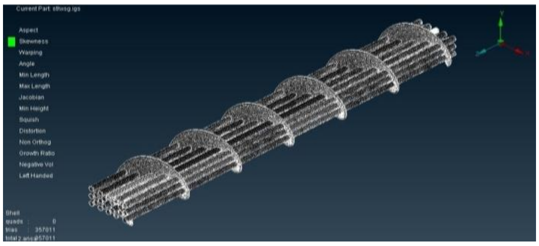


Fig.4 Surface mesh with Helical Baffle

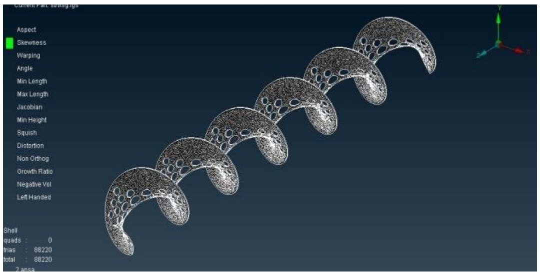


Fig.5 Surface mesh with Helical Baffle

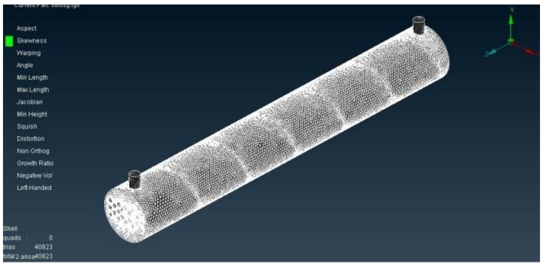


Fig.6 Surface mesh with outer shell

During these Projects work various design consideration of selection of fluid, development of analytical model and analytical consideration assumptions, procedure and input parameters. The development of heat exchanger focus for lower pressure drop and higher heat transfer coefficient. The Results obtain for segmental and helical baffles in FLUENT ANSYS.

The FLUENT ANSYS Results has been obtained for Helical and Segmental Baffles

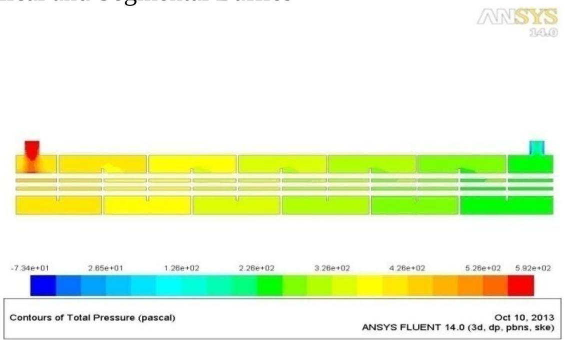


Fig.7 Total Pressure in segmental mid plane

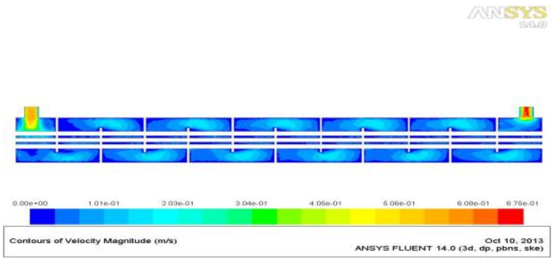


Fig.8 Total Velocity in mid plane

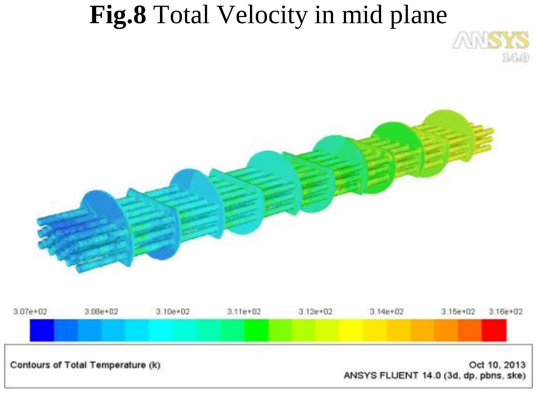


Fig.9 Total Temperature in Segmental Baffle

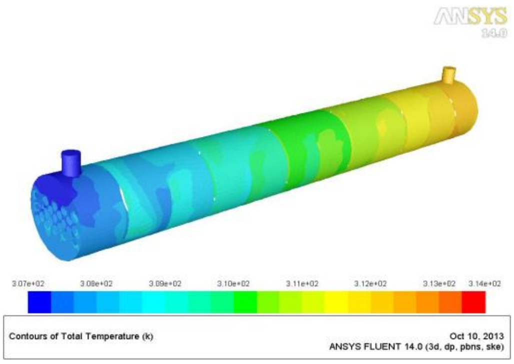
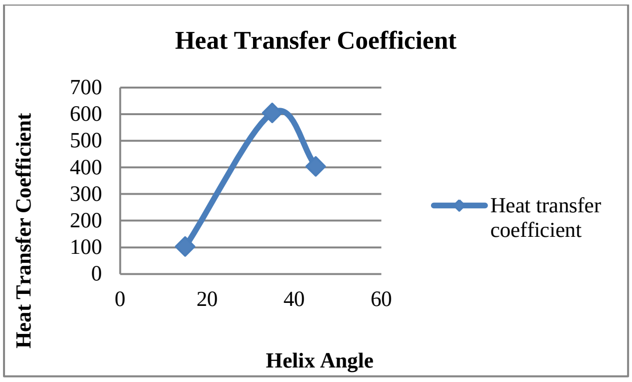


Fig.10 Total Temperature on shell

2. Graphs



Graph 1. Heat Transfer Coefficient vs Helix Angle

2.1Fourier law of heat conduction

$Q = KA \quad T(x) \;\; - T(x+\Delta x) \quad / \Delta x$

K - Thermal Conductivity
A - Area across the Heat Transfer
T - Temperature

2.2 Mean Temperature Difference

$\Delta Tm = \Delta Tm \,[\, (Ti - to) - (To - ti) \,] \,/\, In(Ti - to) \,/\, (To - ti)$

ΔTm – Log Mean Temperature Difference

2.3 Boundary conditions

Most Boundary layer are become Turbulent if their development is unimpeded although it is normal for the turbulent Boundary layer to be proved by a laminar.
Heat Conduction of the Surface in a selected Direction is equal to the Heat Convection at the Surface in the Same Direction
Hot Fluid inlet Temperature (T_1) = 63˚C
Hot Fluid outlet Temperature (T_2) = 58˚C
Cold Fluid Inlet Temperature (t_1) = 33˚C
Cold Fluid Outlet Temperature (t_2) = 37˚C
Fouling resistance for tube side = 0.00299 w/m^{2-k}
Fouling resistance for shell side = 0.00198w/m^{2-k}

3. Tabulation and Calculation

Table 1 Geometric Parameters of Shell and Tube Heat Exchanger

Item	STHXCH	STHXCH	STHXSG
Shell inside Diameter(mm)	207	207	207
Tube outside Diameter(mm)	19	19	19
Tube Pitch	25	25	25
Length of Tube l (mm)	1500	1500	1500
Number of Tubes	24	24	24
Helix Angle	36	20	-
Helix Pitch(mm)	372.5	216.5	-
Baffle Pitch (mm)			118.5
Shell Pass	Single	Single	Double

Table 2 Input Data Tube Side

S.NO	Parameter	Symbol	Shell Side
1	Fluid		Water
2	Volume Flow Rate	Q_S	40 to 80 lpm
3	Mass Flow Rate		0.67 to 1.33 m3/sec
4	Shell Length	L_s	1.123
5	Tube Pitch	P_t	0.0225
6	Baffle cut		25%
7	Baffle Pitch	L_B	0.06
8	Mean Bulk Temp	MBT	30
9	No of Baffles	N_b	6
10	No of Passes		1

Table 3 Input Data Fluid Side

Property	Symbol	Unit	Cold Water(Shell)	Hot Water(Tube)
Specific Heat	Cp	KJ/Kg.K	4.178	4.178
Thermal Conductivity	K	W/m.K	0.615	0.615
Viscosity	µ	Kg/m.s	0.001	0.001
Prandtl 's Number	Pr	-	5.42	5.42
Density	P	1 Kg/m^3	996	996

Table 4 Fluid Properties

S.NO	Parameter	Symbol	Shell Side
1	Tube Side Fluid		Water
2	Volume Flow Rate	(Q_t)	80lpm
3	Mass Flow Rate	(m_t)	1 to 1.4m^3/sec
4	Outer Diameter		0.153
5	Thickness	(D_{ot})	1.123
6	No of Tubes		0.0225m
7	Mean Bulk Temp	(MBT)	30˚ c
8	Tube Side Nozzle ID		1

Results

Table 5 result of Segmental Baffle in STHE

Helix Angle	Heat Transfer Co Efficient(W/m^2k)	Pressure Drop (Pa)	H.T/Pressure Drop
Segmental Baffle	698.094	0.23	3.034

Table 6 Result for Helical Baffle

Helix Angle	H.T Coefficient (W/m^2k)	Pressure Drop (Pa)	Heat.Transfer Coefficient/Pressure Drop
15˚	102.25	36.6	28.4
35˚	604.24	5.23	116.2
45˚	403.73	36.72	109.9

Calculation

Calculation of Parameters in Segmental Baffle

Tube Clearance (c˚)
= [(0.0225-0.0120)]
= 0.0105
Clearance Cross Flow Area (A_s)
= [(0.143*0.0105 *0.06 / 0.0225)]
=4.004E^{-3}
Equivalent Diameter (D_E)
= 4[(0.02256 ^{2}*3.14*0.0144/4) / (3.14*0.012)]
=0.04171m
Maximum Velocity (V_{max})
= (0.001 /3.14/4* 0.143^2)
=0.062297m/s
Reynolds Number (Re)
= [(996*0.0622*0.04171)/0.001]
=2583.8
Prandtl's Number (Pr)
=[(for MBT 30˚)]
=5.42
Heat Transfer Coefficient
= [(0.36*0.6150*2583.98$^{0.55}$*5.42$^{0.33)}$ / 0.04171]
=698.094 W/m^{2}k

No Of baffles
=[(1.123 /(0.06=0.05)]
= 6
Pressure Drop (Δ_{ps})
=[(4*0.009*233.4280.143*7)] / (2.996*0.0417)
=0.23Kpa

Calculation of Parameters in Helical Baffle

For Helix angle(15˚c)
Tube Clearance(c˚)
= [(0.0025-0.0120)]
= 0.0105
Baffle Spacing ($L_{b)}$)
=[(3.14*(0.143)* tan 15)]
= 0.1203
Cross Flow area (a/s)
=[(0.143*0.0105*0.1203) /0.0225)]
= 8.0280E^{-3}
Equivalent Diameter(DE)
=[(4(0.0225^2*3.14 * 0.012^2 / 4) (3.14*0.012)]
= 0.04171m
Reynolds Number(Re)
= [(996* 0.1245* 0.04171) / 0.001]
= 5172.1
Prandtl's Number (Pr)
= [For MBT 30˚C]
= 5.42
Heat Transfer Coefficient
= [(0.36*0.6150*5172.12$^{0.55}$ *5.42 0.33 / 0.04171)]
= 102.25 kpa
No of Baffles
= [(1.123 /(0.1203 + 0.005)
= 7
Pressure Drop(Δps)
= [(4*0.09*29.07^2* 0.143 *7) / 2*996*0.04171)]
= 0.36 kpa

Conclusions

1) In this work An model has been developed to evaluate analysis of a Helical and Segmental Baffle Heat Exchanger as well as the Comparative analysis between the thermal Parameters between the Segmental and helical angle has been showed.
2) From the Numerical Experimentation Results it is Confirmed that the Performance of a Tubular Heat Exchanger can be improved by Helical Baffles instead of Segmental Baffles.
3) Use of Helical Baffles In Heat Exchanger Reduces Shell side Pressure drop, ,pumping cost, weight, fouling etc as compare to Segmental Baffle for a new installation.
4) The Ratio of Heat to increased cross flow area resulting in lesser mass flux through out the shell Transfer Coefficient to Pressure Drop as higher than that of Segmental Baffle.
5) The Pressure Drop in Helical Baffle heat exchanger is Appreciably lesser as Compared to Segmental Baffle heat exchanger.
6) Helical Baffle is the much higher than the Segmental baffle because of Reduced By Pass Effect &Reduced shell side Fouling. The Helical Baffle is three times Higher than the Segmental Baffle.

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