Journal of Research in Science, Technology, Engineering and Management (JoRSTEM)
ISSN: 2456-0197

Design and Analysis of Shell and Tube Heat Exchanger with Different Baffle Inclination for Different Flow Rates for Segmental Baffle Cutout Horizontally and Vertically Using CFD

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Abstract— ***Heat exchangers are widely use in during the condensation, evaporation, oil refineries, other large petrochemical plants and automobile function. Shell side analysis of single phase shell with tube heat exchanger during particular stream rate and baffle slant angle dependencies of the pressure drop , heat transfer rate and heat transfer coefficient be investigated by numerical models for both horizontally and vertically placed baffle cut.. The geometry of the model is made in SOLID EDGE v19 and meshed in ANSYS ICEM CFD 15.0. The fluid stream with temperature fluids within the shell be resolved by a commercial CFD software device ANSYS CFX 15.0. During current work attempt were prepared to examine the impacts of different baffle slant angle namely 150, 250 with various stream rates namely 1 kg/s, 2 kg/s. The 36% baffle cut and 16% baffle spacing is used for modeling the heat exchanger. The simulation results for single phase shell with tube heat exchanger for both horizontal as well as vertical baffle cut are compared for the performance. The outcome observed to be perceptive for the turbulence model. From the CFD simulation result 250 slant angle for stream rate of m=2 kg/s of the horizontal placed segmental baffle cut gives 9.27% decrease in pressure drop, and 51% raise in heat transfer. Horizontally placed baffle gives 0.06% better results compare with vertically placed baffle. From CFD simulation results pressure drop, shell side outlet temperature, heat transfer coefficient, heat transfer rate and recirculation near the baffles are determined.***

Keywords*— *Baffle slant angle, horizontal as well as vertical baffle cut, pressure drop, heat transfer coefficient.

I. INTRODUCTION

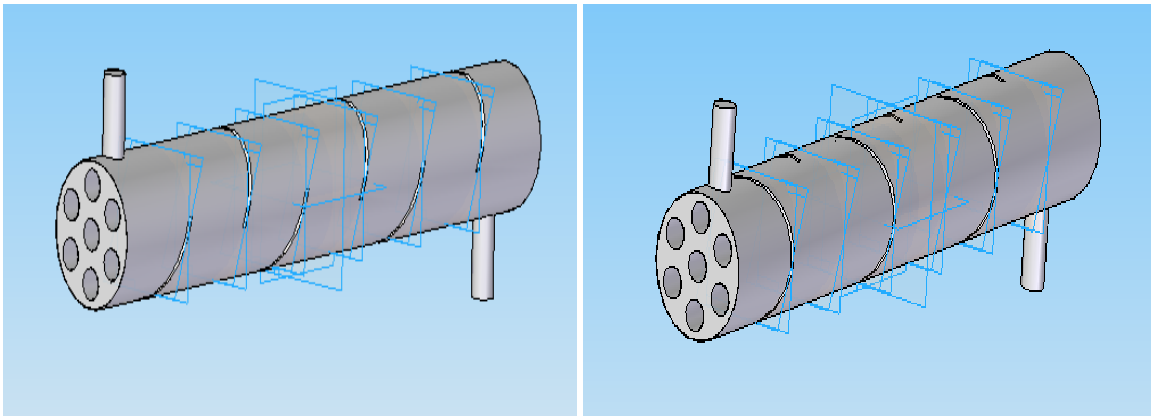
Heat exchanger be a device that use to make easy the exchange of heat among the two solutions that are at dissimilar temperatures. In majority of the heat exchangers the two solutions are divided by a solid wall and so that the two solutions are not direct contact with both other. Typically the single solutions is iced and the further solutions is heated and the process solutions, generally be heated or iced earlier than the process go through a phase change.

Shell and tube form heat exchanger be a not direct contact form of heat exchanger and consist a sequence of tube during which solo of the solutions run. The shell be bottle shape designed for shell solutions and generally in the form of a cylindrical in profile by a rounded section. Although shells with dissimilar shapes be use in a exact application.

For this revise E shell be consider, which are usually a single bypass shell. And E shell be a mainly use appropriate toward its inexpensive along with effortlessness, it have the maximum log-mean high temperature differences (LMTD) Correction factors. Even though tube might include one or else many passes and near be single pass on the shell face, although extra solutions flow with in shell above the tube to live heated or else iced. Various sizes of shell with tube heat exchangers be generally use during a industrialized operations and power conversion system. The Tubular exchanger manufactures organization(TEMA) frequently publish standard with design recommendation. Tube region and shell region solutions be divided tube sheet, Gaddis [9]. The heat exchanger models usually use during this study be a minute sized one. compare toward major flow every part of the leakage with go around stream do not exist or else insignificant, Ender Ozden and Ilker Tari [4].Baffles use to hold the tubes for preventing tube shaking, structural rigidity and sagging toward divert the stream crossways to bundle to obtain high warm transfer coefficient. Baffle space be center row space among two nearby baffle, Sparrow and Reifrchncider [10], Li and Kottke [11], Su Thet Mon Than etal [12]. Baffle is provide by a cut (BC) Which be articulated with a proportion of segment elevation near shell indoor span. Baffles cut preserve to varied among 15% with 45% of a shell indoor diameter. Generally a predictable shell with tube warm exchanger effects a elevated shell face, pressure drop with arrangement a recirculation region next to the baffles. And the majority of the researches nowadays carry on helical baffles, which gives a improved performance than the lone segmental baffles but they occupy a elevated manufacturing, installation with maintenance price. The success with price are the two significant parameter during a heat exchanger drawing. Thus, in order towards better a thermal performance on a logical price of shell with tube warm exchanger, baffle be provided during the current revise with various slants in order to maintain logical pressure drop acrosswarm exchanger. The difficulty by a investigational technique involve a quantitative sketch with a stream phenomenon by the dimensions dealing through lone quantity at a time used for imperfect vary of difficulty with the working condition. Computational fluid dynamics [CFD] be currently conventional industrialized design device, for offer apparent reward.

In present revise, a full 3600 shell with tube warm exchanger CFD model be consider for model a geometry, like perfectly possible, the stream arrangement with temperature allocation within the shell is obtain.

II. GEOMETRY MODELING



(a) (b)

Fig. 1 3-D view of baffles with tubes in STHX for a) horizontal and b) vertical 36%baffle cut for 25^0

Geometry modeling is done using Solid Edge V-19 software. The above Fig 1 shows the detail Isometric geometric models of shell with tube warm exchanger for 250 horizontalas well as vertical baffle cut. The considered models are horizontal as well as vertical baffle cut for different baffle inclination angles are modeled dividely. After modeling the model in solid edge the model is saved as parasolid file. Then the parasolid file is opened in the ICEM CFD 15.0 for meshing . By importing the model some surfaces of the model gets deleted and overlapped. So the surfaces are cleaned and deleted before meshing.

TABLE I: GEOMETRIC DIMENSION OF SHELL WITH TUBE WARM EXCHANGER [9]

Span of warm exchanger,(L)	610 mm
Interior radius of the Shell,(R_S)	45 mm
External radius of the tube,(R_0)	10 mm
Geometry of Tube Bundle with Pitch	Triangular, 30 mm
Number of Tubes, (N_T)	7
Baffle Cut,(B_C)	36%
Thickness of the Baffle	4 mm
Inner Baffle spacing, (B)	86 mm
Number of Baffle,(N_B)	6
Variety of baffle cut	Horizontal, Vertical
Baffle inclination Angle,(θ)	15^0,25^0

III. MESH GENERATION

After modeling, model is imported to ANSYS ICEM CFD 15.0 for meshing. For meshing the model the volume mesh is considered. Meshing is done till the accuracy of the mesh is achieved. Mesh generation is performed using ANSYS ICEM CFD 15.0. The surfaces of a model is meshed utilizing All Tri components. The arrangements of volume is meshed utilizing a Tetrahedral components. Keeping in mind the end goal to catch the both boundary layers and velocity, the whole replica is discretized utilizing a 2D tri work components for every surfacewith tetra work components for a 3D volume arrangements components, and are extremely precise which include a smaller amount calculation exertion. The whole geometry model is isolated into 8 parts to be specific, inlet, inlet surface, shell, tubes, baffles plate, exit surface , along with exit.

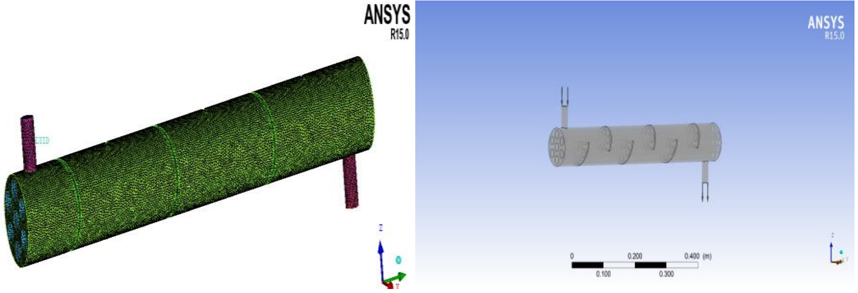


Fig. 2 Descretized arrangements domine for shell with tube heat exchanger with uniform volume 3-dimensional tetrahedral mesh

TABLE II: NODES AND ELEMENTS FOR SHELL WITH TUBE HEAT EXCHANGER FOR UNLIKE BAFFLE SLANT ANGLE FOR BOTH HORIZONTAL AND VERTICAL BAFFLE CUT

Type	Angle	Nodes	Elements
Horizontal baffle cut	15^0	138068	651998
	25^0	105058	502213
Vertical baffle cut	15^0	208067	1052292
	25^0	104552	499924

IV. BOUNDARY CONDITIONS

Following are the assumptions incurred on the present analysis.

1. Flow is turbulent,
2. Flow is steady,
3. Coupled implicit solver.

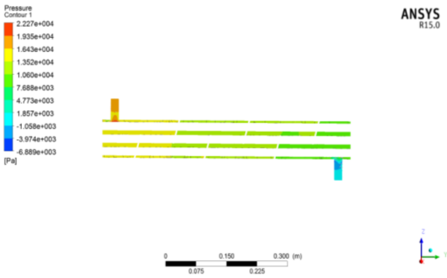
TABLE III: BOUNDARY CONDITION USED FOR A SHELL WITH TUBE WARM EXCHANGER

Working solutions of both shell with tube be	Water
Temperature of the shell inlet	300K
Temperature at the Tube wall	450K
Gauge Pressure at the exit of the tube	Zero Pascal
Inlet velocity of the Profile is	Uniform
Heat flux be assigned toward the shell outer wall be	Zero
No slip condition be assigned for all surfaces	-

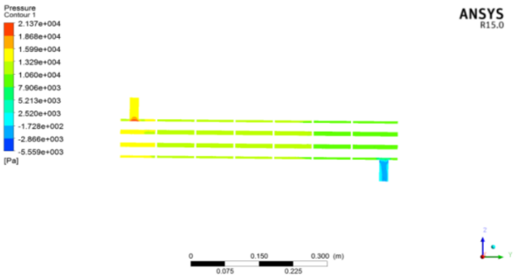
V. RESULT AND DISCUSSION

A. Pressure Variation (for m= 1 kg/s)

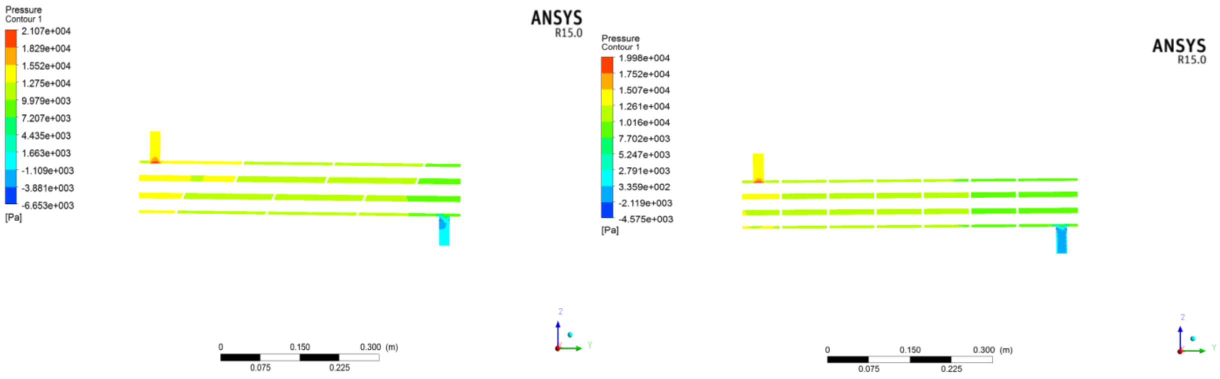
For Horizontal Baffle Cut *For Vertical Baffle Cut*



(a)



(a)

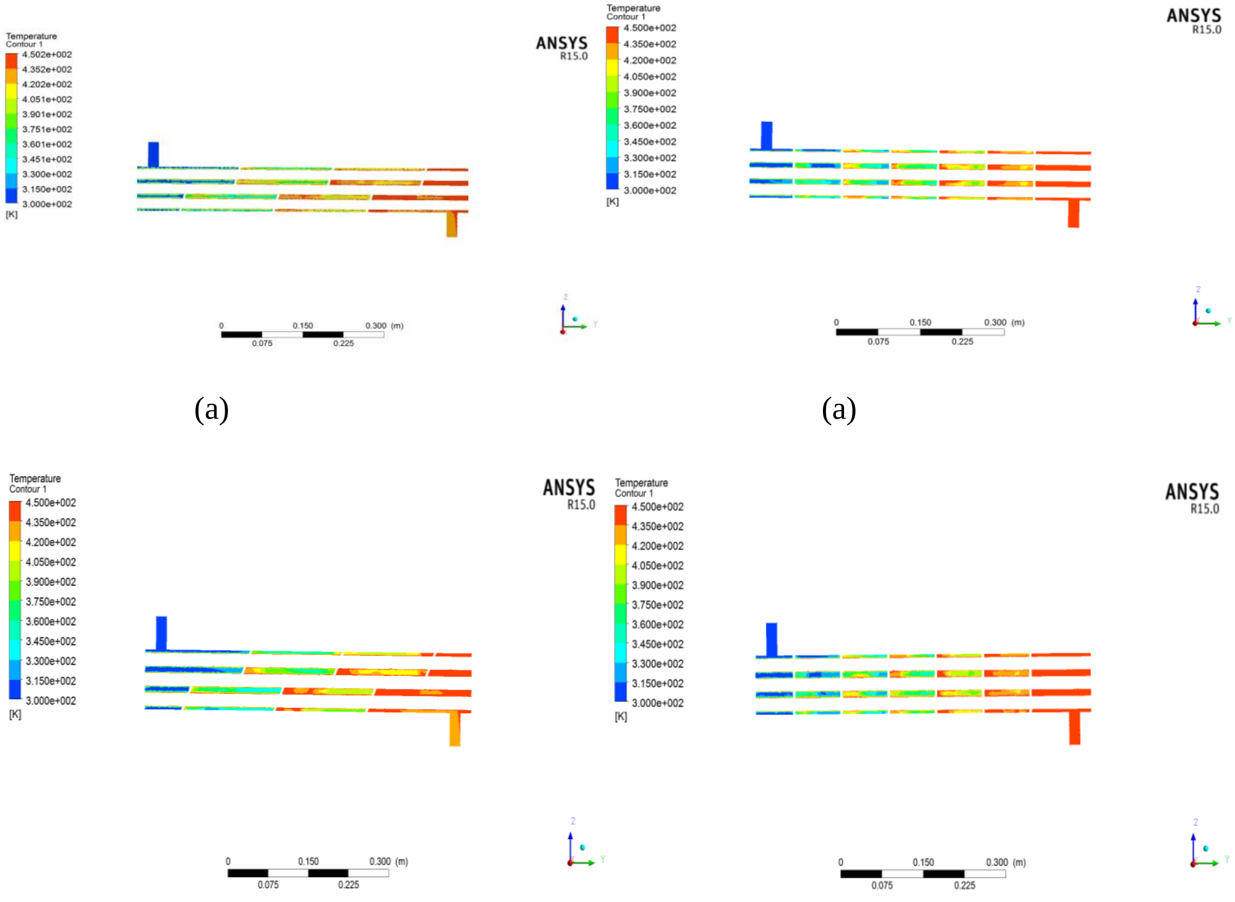


(b) (b)

Fig. 3 Pressure allocation across shell for horizontally as well as vertically placed baffle for (m=1 kg/s) a)15^0,b)25^0 baffle inclination

B. *Temperature Variation (for m= 1 kg/s)*

For Horizontal Baffle Cut *For Vertical Baffle Cut*

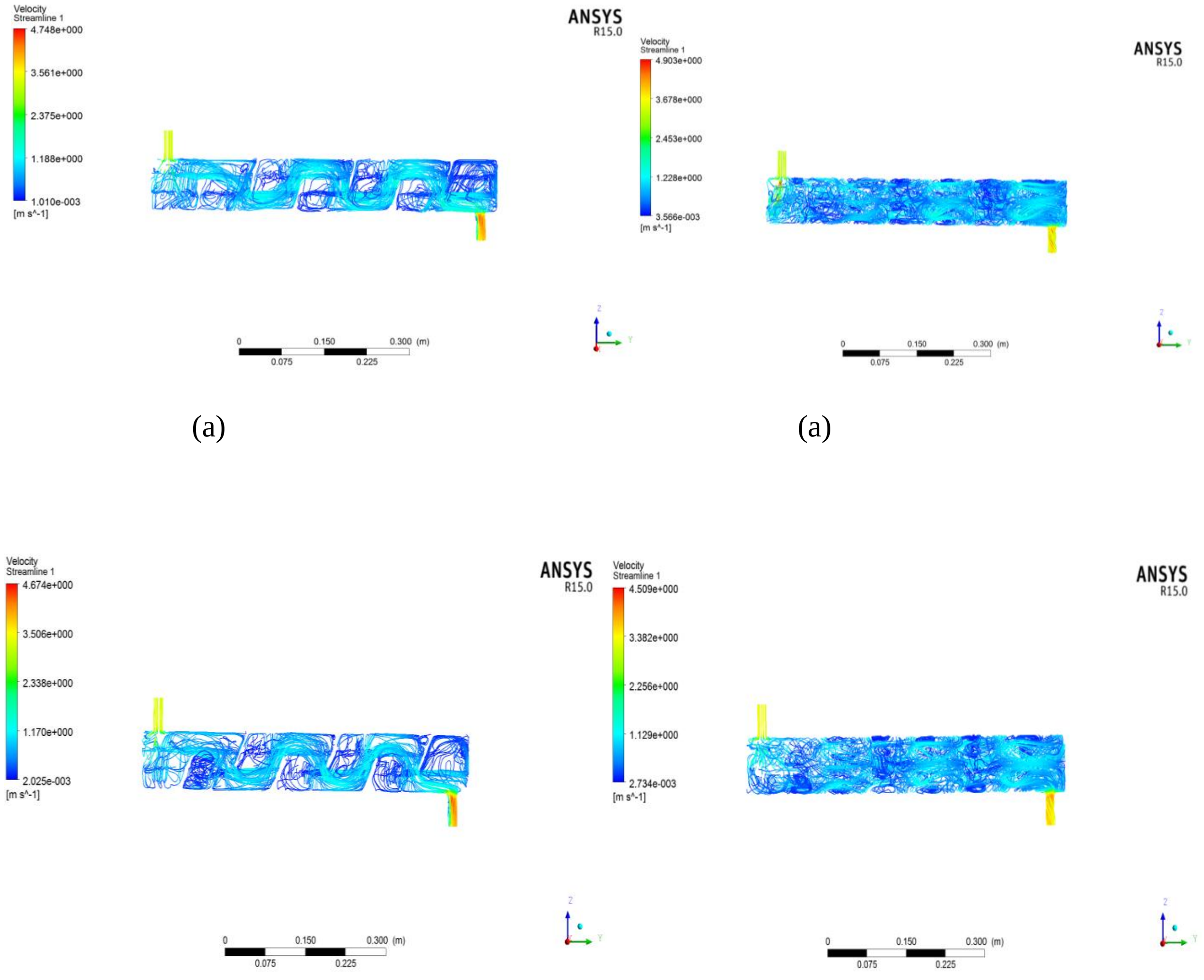


(b) (b)

Fig. 4 Temperature allocation across shell for horizontally as well as vertically placed baffle for (m=1 kg/s) a)15^0,b)25^0 baffle inclination

C. Variation of Velocity Stream lines

For Horizontal Baffle Cut *For Vertical Baffle Cut*



(a) (a)

(b) (b)

Fig. 5 Velocity stream lines across shell for horizontally as well as vertically placed baffle for (m=1 kg/s) a)15^0,b)25^0 baffle inclination

Table IV demonstrates the general calculation and correlation of CFD analysis for both horizontally placed segmental baffles along with vertically placed segmental baffles of shell with tube heat exchanger. The review is centered around heat exchange coefficient and pressure drop regarding not at all like fluid stream rates under not at all like baffle slants for both horizontally placed and vertically placed segmental baffle cut.

By horizontally placed baffle shell with tube warm exchanger, shell side pressure drop declines with raise by baffle slant at a given stream velocity. However, the event that vertically placed baffle of shell with tube warm exchanger, shell face pressure drop diminished by means of raise in baffle slant angle with shell side pressure drop raises with raise by fluid stream rate. Relating varieties also happens for heat exchange coefficient.

D. Impact of baffle slant by pressure drop with exit temperature

From CFD recreation comes about, for a settled tube divider with shell bay temperature, shell face exit temperature with pressure drop qualities used for shifting arrangements stream rate given in Table 6.1. In this effort, fluid stream rates esteems used for 1 kg/s as well as 2 kg/s. Table 6.1 demonstrates that the comparing estimations of shell exit temperature are diminished marginally, the pressure drop and heat exchange coefficient esteems are raised.. The exit temperature with baffle slant angle there is no much variation for horizontally placed segmental baffle and it remains constant for vertically placed segmental baffle with varying stream flow rate as shown in the Table 4.

TABLE IV: GENERAL CALCULATION WITH COMPARISON FOR HORIZONTALLY AS WELL AS VERTICALLY PLACED SEGMENTAL BAFFLE FOR SHELL WITH TUBE HEAT EXCHANGER

STHX baffle geometry	**Baffle slant Angle (degree)**	**Fluid stream rate (kg/s)**	**Shell side pressure drop (Kpa)**	**Shell face exit temp(k)**	**Heat Transfer coeff. (KW/m^{2}k)**	**Total heat transfer rate(KW)**
Horizontally placed segmental Baffle		1	22.2654	450.92	20.3798	629.447
	15^0	2	88.588	450.284	35.6791	1258.311
		1	21.0664	450.187	21.0774	628.167
	25^0	2	83.7403	450	36.6736	1256.343
Vertically placed segmental baffle		1	21.3712	450	25.2778	628.159
	15^0	2	85.219	450	43.8836	1256.318
		1	19.9793	450	20.2618	628.138
	25^0	2	79.1992	450	35.6637	1256.275

E. Horizontal segmental baffle cut for STHX

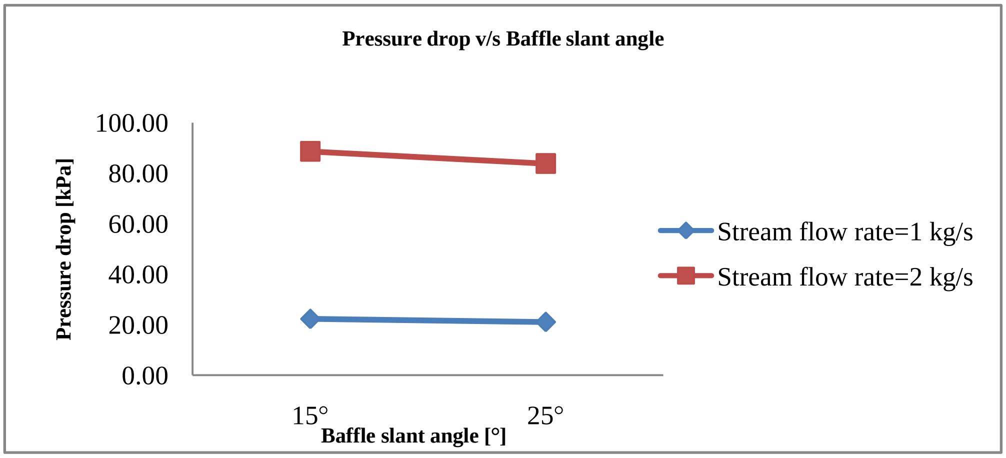


Fig. 6 Impact of baffle slant angle on pressure drop for horizontally placed segmental baffle

The shell side pressure drop diminishes with raise during baffle slant angle from 15^0 because due to smoother guidance of stream and obstacles to stream will diminishes by raise of slant angle to 25^0. From the above Fig 6 it demonstrates that by raise in stream rate from (m=1 kg/s to m=2 kg/s) the pressure drop raises. Pressure drop raised 9.27% for 25^0 compared with 15^0, because by tilting the baffle plate above 15^0 the area of stream from shell to first baffle near shell inlet increases due to smoother guidance of stream, as obstacles to the stream gets decreased by increasing baffle slant angle, so pressure allocation decreases for little vary in temperature and recirculation is more for 15^0 and by increasing the baffle angle the recirculation near the baffle gets decreased. By raising above 2 kg/s pressure drop raises quickly with little diversity by exit temperature. By this we can say that a 15^0 baffle slant angle result a logical pressure drop byhighest shell exit temperature. By this conclude that 25^0 baffle slant angle for fluid flow rate (m=2 kg/s) results a improved performance compare with 15^0 angle.

F. Vertical segmental baffle cut for STHX

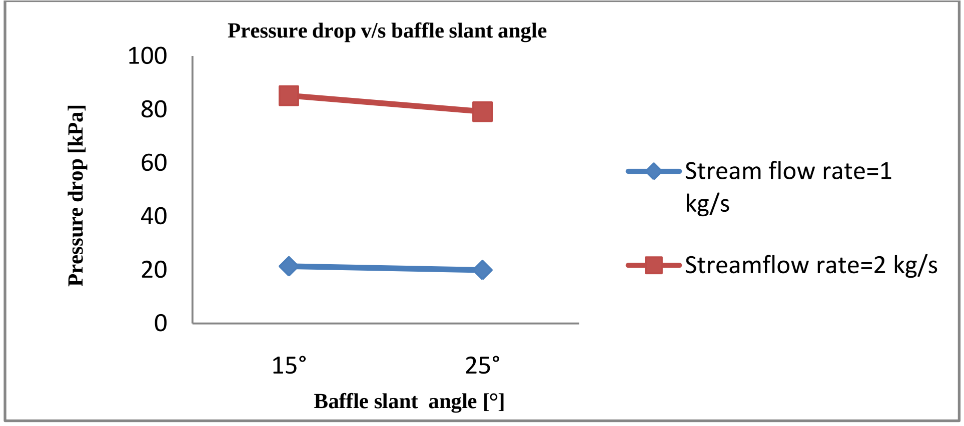


Fig. 7 Impact of baffle slant on pressure drop for vertically placed segmental baffle

For vertically placed segmental baffle the shell side pressure drop diminish through subsequently raised by raise in baffle slant angle i.e., 15^0 to 25^0. Pressure drop is decreased slightly for mass flow rate (m=1kg/s), with raise of mass flow rate above m=1 kg/s the pressure drop decreases by 9.27% more for 15^0 to 25^0 baffle inclination angle, because by tilting the baffle plate above 15^0 the area of stream from shell to first baffle near shell inlet increases due to smoother guidance of stream, as obstacles to the stream gets decreased by increasing baffle slant angle, so pressure allocation decreases for little vary in temperature and recirculation is more for 15^0 and by increasing the baffle angle the recirculation near the baffle gets decreased . For horizontally placed segmental baffle gives 0.06% more when compared with vertically placed segmental baffle because for lone phase fluid on shell face, the vertical baffle does not reduces accumulation of deposit at base of shell along with do not prevent stratification, so pressure drop reduce.

G. Comparison of Heat transfer coefficient with pressure drop for horizontal and vertical segmental baffle cut STHXS (m=2 kg/s)

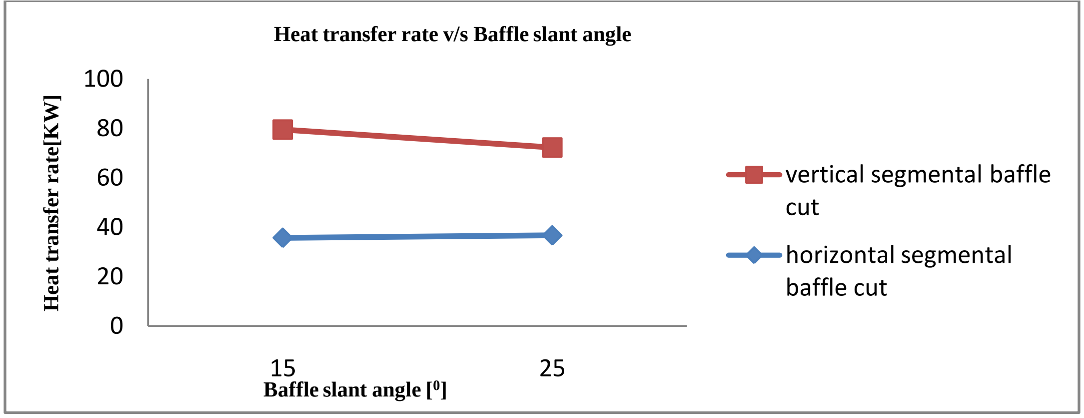


Fig. 8 Comparisons of heat transfer coefficient used for both horizontally as well as vertically placed segmental baffles

Figure 8 demonstrate the comparison of heat transfer rate used for horizontal as well as vertical segmental baffle cut of shell with tube heat exchanger with fluid flow rate 2 kg/s. For horizontal segmental baffle cut the heat transfer rate steadily raises with baffle slant angle raise . But in vertical segmental baffle cut the heat transfer rate it decreases with raise in inclination angle because for lone phase fluid on the shell face, the vertical baffle cut does not reduces accumulation of deposit at the base of shell along with do not prevent stratification, so pressure drop reduces, heat transfer coefficient increases.

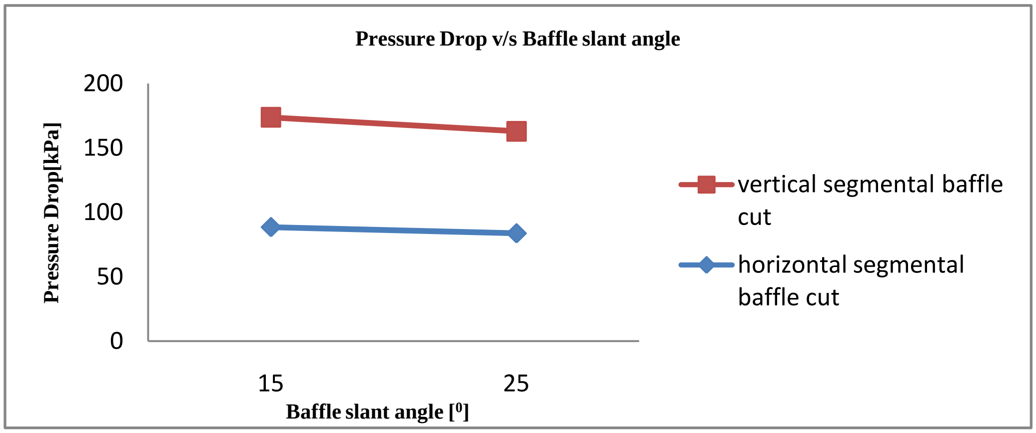


Fig. 9 Comparison of shell face pressure drop for both horizontally as well as vertically placed baffles

Figure 9 show the comparison of pressure drop for unlike baffle slant angle used for both horizontal segmental baffle cut and vertical segmental baffle cut of a heat exchanger for fluid flow rate (m=2 kg/s). In horizontal segmental baffle cut the pressure drop gradually decreases by 0.06% more compared with vertical segmental baffle cut because by increasing slant angle it provides smoother flow than the 15^0.

VI. CONCLUSION

Following conclusions are drawn

- Shell face CFD analysis of shell with tube warm exchanger for single phase fluid is modeled with sufficient detail to determine flow as well as temperature field.
- By changing the baffle slants for 15^0& 35^0 for two different mass stream rates are 1kg/s, 2kg/s and baffle cut value be 36% shell diameter and baffle spacing be 16% of the shell length for both horizontal and vertical baffle cut.
- Pressure drop is minimum 85219 Pa in vertically placed segmental baffle and is maximum 88588 Pa in horizontally placed segmental baffle, from above results it is observed that pressure drop is 0.06% more in horizontally placed segmental baffle compared with vertically placed segmental baffle, because for single phase fluid horizontally placed segmental baffle removes the deposition sediments present in the shell.
- If the slant angle increase from 15^0 to 25^0, pressure drop for 15^0 be 88,588 Pa and for 25^0 is 83,740 Pa, from above results it is observed that pressure drop is 9.27% decreased for 25^0 baffle slant angle compared with 15^0.
- From the geometry the stream rate should be 2 kg/s. If increases above 2 kg/s the pressure drop increase quickly for small vary during the exit temperature.
- Hence, maximum baffle slant angle can be 25^0, if it increased above $25^0$the center row of tubes not supported , hence baffle cannot be used effectively.
- From above results, we conclude that horizontally placed segmental baffle of shell with tube warm exchanger for 25^0 slant angle for stream rate of 2 kg/s gives better results compared with 15^0 baffle slant angle

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