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Performance of Shell and Tube Heat Exchanger to Study Shell and Tube Side Pressure Drop and Heat Transfer Coefficient by Varying Geometry

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Abstract *- the effect of baffle spacing on pressure drop, heat transfer coefficient and overall heat transfer coefficient is considered in a Shell and Tube Heat Exchanger with single segmental baffles and staggered tube layout. The effects of baffle spacing are considered. Shell and tube heat exchanger with single segmental baffles was designed with same input parameters using Kern's theoretical method and Bell-Delaware method.*

Keywords *- Bell Delware method, HTRI, Kern's methods, Pressure drop, Heat transfer coefficient and Shell and Tube Heat Exchanger*

I. INTRODUCTION

Heat exchanger is an instrument build for efficient heat transfer from one medium to another in order to bear and process energy. Heat exchangers had always an important part to the lifecycle and procedure of a lot of systems. They usually used in petrochemical plants, petroleum refineries, chemical plants, natural gas processing, air-conditioning, refrigeration, and automotive applications.

Shell-and-tube heat exchangers (STHEs) are the most type of heat exchanger used in industrial processes as in nuclear power stations as condensers, steam generator in pressurized and water reactor plants, and feed water heaters. STHEs are also proposed for many others alternative energy applications as ocean thermal and geothermal [8].

Shell and tube heat exchangers are ''the cornerstone" of industrial process, more than any other type of heat exchangers. They are established actions for design and manufacturing, many years of acceptable service, and availability of codes and standards for design and fabrication. They can be applied to different industrial processes for large range of operating conditions, such as chemical industry, power production, food processing, distillation, cryogenics, and waste heat recovery [9].

The application of single-phase shell-and-tube heat exchanger is relatively large because these are used in chemical, petroleum, and power generation and process industries. Shell and tube exchanger is a pressure vessel with lots of tubes inside of it. One process fluid is flows through the tubes of the exchanger while the other flows outside of the tubes inside the shell.

Shell and tube heat exchanger design are consider the correlations for the Kern method and Bell-Delaware method are the most regularly used. Kern method is mostly used for the first round design and provides conservative results. The Bell-Delaware method was further accurate method and can provide detailed results. It knows how to predict and estimate pressure drop and heat transfer coefficient with improved accuracy. The Bell-Delaware method was actually the rating method and it preserve suggest the weaknesses in the shell side deign but it cannot point out where these weaknesses are.

1.1 Heat Exchanger Classifications

At heat exchangers are available in many configurations. Depending upon their purpose, process fluids, and mode of heat transfer and flow, heat exchangers can be classified. Heat exchangers can transfer heat through indirect contact with the fluid or through direct ways. Heat exchangers are classified on the basis of shell and tube passes, arrangement of tubes, smooth or baffled surfaces, and types of baffles. It is classify through flow arrangements as fluids can be flowing in opposite to each other, same direction and normal to each other. The selection of a particular heat exchanger configuration depends on some factors. The factors can include maintenance, flow rates, the area requirements, and fluid phase.

II. Literature review related to shell and tube heat exchanger

The shell and tube heat exchanger has a great variety of process and phenomena which is the amount of the material is published regarding shell and tube heat exchanger which depict different factors affecting the thermal efficiency of the shell and tube heat exchanger. On the basis of that a brief summary is reviewed as follow

Ender Ozden, Ilker Tari It was studied a small shell-and-tube heat exchanger is modelled for CFD simulations. Mesh and turbulence model is investigated for sensitivity of the simulation results to modelling choices. It was selecting a suitable mesh, a turbulence model, a discretization scheme and, simulations are performed for three unlike shell side flow rates by varying baffle spacing and baffle cut. The results were used for calculating shell side heat transfer coefficient and pressure drop. These results were compared with the Kern and the Bell-Delaware results.

From this study it was concluded that the simulation results are compared with the results from the Kern and Bell-Delaware methods by varying the baffle spacing between 6 and 12, for 0.5, 1 and 2 kg/s shell side flow rates and the baffle cut values of 36% and 25%. From the observations Kern method always under predicts the heat transfer coefficient. It is observed that the CFD simulation results are in very good agreement with the Bell-Delaware results. The results are also responsive to the baffle cut selection, for this heat exchanger geometry 25% baffle cut gives slightly improved results.

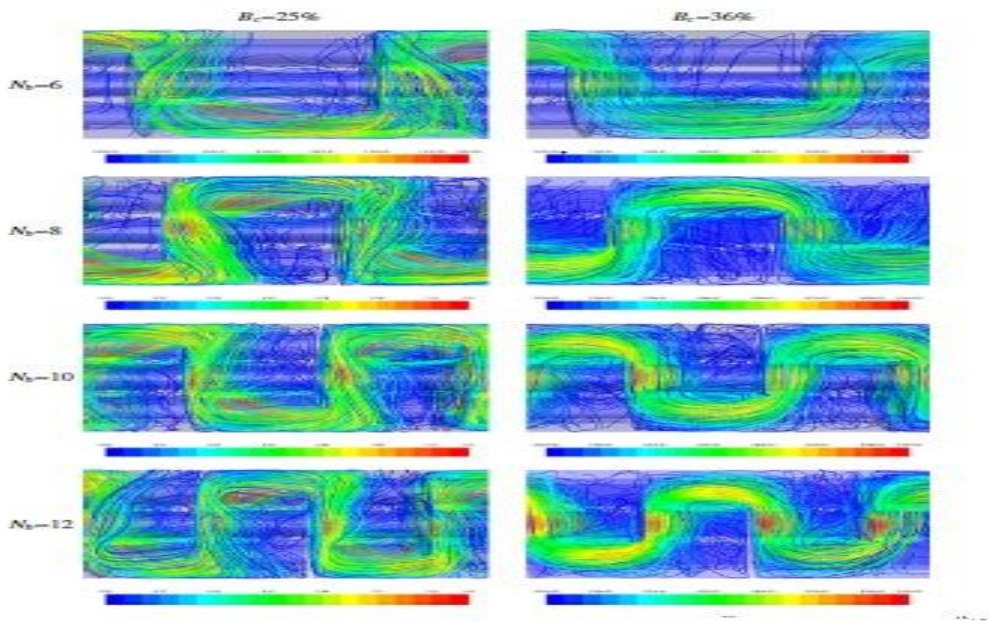

Figure 1. Particle velocity path lines for 0.5 kg/s mass flow rate Left column is for Bc = 25% and right column is for Bc = 36%. Rows from top to bottom are for Nb = 6, 8, 10 and 12

Gabriel Batalha Leoni To performed CFD simulations of a small shell and tube heat exchanger with single segmental baffles effects of baffles clearances on velocity, temperature and pressure profiles in the shell side flow. Two turbulence models have assess, the k-e model, due to its wide usage in the literature to simulate heat exchangers of all kinds. The Shear Stress Transport (SST) model, since it solve near wall regions which are believed to be important in the present work. Geometries with and without baffle clearances was compared with CFD simulations, carried out with ANSYS Fluent 15.0.

From this study it was concluded that the effect of baffle clearances on a small heat exchanger designed using the software HTRI. At two turbulence models were tested k-e and the SST, in order to prove their suitability to the problem. From the result SST model could capture more accurately the fluid flow characteristics close to wall regions and consequently, heat transfer effects, given that closer results to HTRI. It was concluded the SST model was considered more appropriate for the present CFD case. The contrast of CFD and HTRI results for the geometry with baffle clearances showed good agreement, especially for the shell side outlet temperature.

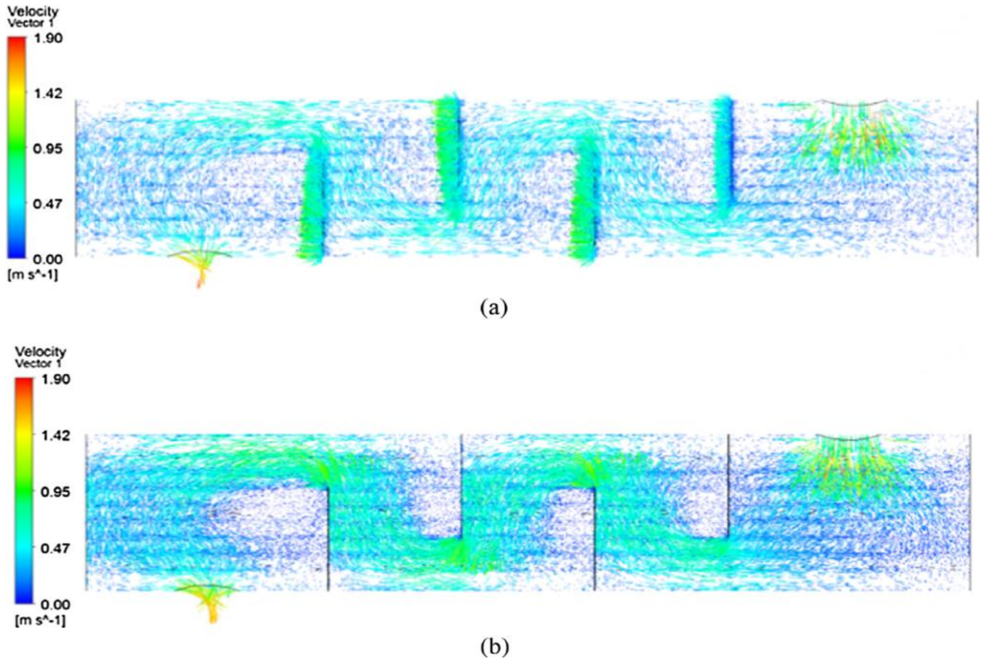

Figure 2. Velocity vectors coloured by their intensity in the geometry (a) with and (b) without leakage streams

W. Roetzel and D. Lee It was investigated experimentally the thermal performance in a shell and tube heat exchanger with segmental baffles by changing five variables stream flow direction, shell side flow rate, tube side flow rate, clearance between baffles and shell, and distance between baffles.

In different experimental values of *U* for counter current flow under different distances between baffles and different tube-side Reynolds numbers. For different distances, the *U* curves connect smoothly when the clearance between baffles and shell was small. However, when the clearance increases, the *U* curves was do not connect smoothly for different distances. The result shows that the apparent overall heat transfer coefficient was strongly influenced by the leakage between baffles and shell.

Kiran K to discuss the investigation of baffle spacing effect on shell side heat transfer characteristics in shell and tube heat exchanger using computational fluid dynamics. To evaluate the effect of baffle spacing on heat transfer and fluid flow characteristics of a single pass and 35% baffle cut, single phase, single segmental baffled shell and tube heat exchanger the three dimensional CFD simulations were carried out. To measure for different baffle spacing and for different mass flow rate with the variation in Shell side Outlet temperature, Heat transfer coefficient, Shell side Pressure drop and Total transfer rate.

They obtain from the CFD simulation of fixed tube wall and shell inlet temperatures resulted values of shell side heat transfer coefficient, pressure drop and heat transfer values. The simulation results were found by changing the baffle spacing between shell 4 and 10 for 0.5, 1 and 1.5 kg/sec shell side flow rates. For small shell and tube heat exchanger she shell side CFD analysis of a modelled with adequate detail to determine the flow and temperature parameters.
From the above results concluded that the sensitivity of Shell side Outlet temperature was less with respecting to baffle spacing where as it had a significant change with respecting to mass flow rate**.** Heat transfer coefficient, Shell side Pressure drop and Total transfer rate increases w. r. t. both baffle spacing and mass flow rate. For better performance of Shell and Tube Heat Exchanger one should design with considerable change in Shell side Pressure drop. The best operating parameters for the STHE depending upon the need and heat transfer characteristics one can predict and choose from the above baffle spacing and mass flow rate.
Kirubadurai.B, R.Rajasekaran, K.Kanagaraj, P.Selvan, Were to study the design of the shell and tube heat exchanger, which was one among the majority type of liquid to liquid heat exchangers. The design parameters such as the pitch ratio, tube length, and tube layer and baffle spacing had a direct effect on pressure drop and effectiveness, they were considered to be the key parameters in this work. The analysis of orifice baffle and convergent divergent tube in a shell and tube heat exchanger were experimentally carried out. The maximum heat transfer coefficient and a lower pressure drop recently designed heat exchanger were obtained. From result of numerical experimentation to observe that by modified baffle and tube than the segmental baffle and tube arrangement the performance of heat exchanger increases.

It showed the qualified analysis of the thermal parameters between the segmental and new model heat exchanger had developed to evaluate analysis of new and segmental baffle and tube heat exchanger. The result of numerical experimentation was confirmed that the performance of tubular heat exchanger can improved segmental heat exchanger by modified heat exchanger. A new installation the modified baffles heat exchanger reduces shell side pressure drop, fouling, pumping cost, and weight as compare to segmental baffle. The pressure drop in modified compared to segmental baffle heat exchanger was appreciably less. To increase cross flow area results in less mass flux during the shell transfer coefficient to pressure drop as higher than segmental baffle. The modified heat exchanger was two times higher than the segmental heat exchanger. Also modified baffle was the much advanced than the segmental baffle because of reduced by shell side fouling and by pass effects.

Dogan Eryener studied that the thermo economic analysis optimum baffles spacing for shell and tube heat exchanger. The objective of thermo economic optimization is to determine the minimum annual total cost for a thermal system. The results notice were then used to display how the optimum baffle spacing ratio is affected by the varying values of the heat exchanger geometrical parameters. And observe the variation of exergy profit with baffle spacing for the case of fixed area with different tube layouts. It was display the result the large baffle ratio is increase with exergy destruction and exergy ratio also reduce. It was discuss about the variation of annual total cost for the case of fixed heat transfer with the square tube layout with the ratio of baffle spacing to shell diameter. It was present the variation between optimum ratios of baffle spacing to shell diameter and tube length for the case of fixed area with different tube layouts, and outer diameter for the case of fixed area with different tube layouts, and heat exchanger area for the different tube length, and number of tubes for the case of fixed heat transfer with different tube layouts. The optimum ratio is strongly affected by the pitch ratio and tube layout. The optimum ratios increase as the heat exchanger area increases.

Ali Falavand Jozaei et al studied the optimization of baffle spacing on heat transfer, pressure drop and estimated price in shell and tube heat exchanger. To analysed numerically using EES and Aspen B-JAC software for the shell and tube heat exchanger. In this paper considered the effects of baffle spacing from 4 inches to 24 inches. The results show that when baffle spacing are minimum (4 inches) U/Δp ratio is low because pressure drop is high; however, heat transfer coefficient is very considerable. After that with the increase of baffle spacing, (U/Δp) ratio increases, pressure drop rapidly decreases and OHTC also decreases, but the decrease of OHTC is lower than pressure drop. After baffles spacing more than 12 inches, variation in pressure drop is gradual and approximately constant and OHTC decreases; U/Δp ratio decreases again; variation of both estimated price and shell side pressure drop is negligible. Optimum baffle spacing was recommended between 8 to 12 inches for satisfactory heat duty, low pressure drop and low cost. When baffle spacing reaches to 24 inches, STHX will have minimum pressure drop, but OHTC decreases, so required heat transfer surface increases and U/Δp ratio decreases.

Durgesh Bhatt et al carried out the shell and tube heat exchanger performance analysis. The analysis was done by varying the tube materials which was considered the copper and brass material. In this paper discuss detail in the following terms: - varying the tube diameter, length, and pitch layout, temperature of tube, material of tubes and number of tubes for improving the rate of heat transfer. To calculate the numerical analysis by the Kerns method to find out the heat transfer coefficient, shell side pressure drop, tube side pressure drop, overall heat transfer coefficient, over surface and over design. For further optimization of the design to develop the excel program for shell and tube heat exchanger. The result was noticed the copper material gave better the heat transfer rate than the brass material. It observed from the result the baffle spacing was decreased the number of baffle would increase and also increase the shell side Reynolds number. That was lead to increase in overall heat transfer coefficient. But at the time the pressure drop was increase. To recommended for getting better the heat transfer from the baffle spacing variation guide to heavy operation cost.

S.M. Shahril et al studied the thermo hydraulic performance analysis of a shell-and-double concentric tube heat exchanger using CFD software ANSYS FLUENT 14.0. For thermo hydraulic performances for different mass flow rate of the hot fluid are compared shell and double concentric tube heat exchanger having fixed inner tube diameter with classical shell and tube heat exchanger. The result notice that the average percentage increase in overall heat transfer rate per pressure drop of SDCTHEX with inner tube diameter equal to 8/12 mm/mm. It shows that nearly 343% higher than that of STHEX while the total friction power expenditure of SDCTHEX is reduced by around 85.5%as compared to that of STHEX.

The result of simulation observed that, the SDCTHEX has higher heat transfer performance while maintaining a lower pressure drop. Also discuss the effectiveness for STHEX and SDCTHEX for different hot fluid mass flow rates. The result shown as both STHEX and SDCTHEX increased with increased the hot fluid mass flow rates. The effectiveness of SDCTHEX is higher than STHEX by 34.7% at the maximum hot fluid the mass flow rate of 60/30 kg/s. It is also found that higher effectiveness was achieved at lower inner tube diameters as well with higher hot fluid mass flow rates which would be economical. It suggests that the SDCTHEX might be ideal choice to replace the classical STHEX in heat exchanger industrial applications.

Devanand D Chillal et al carried out effects on heat transfer rate for shell side in TEMA E-type shell and tube heat exchangers due to variation in the baffle cut percentage using CFD software. In this paper to consider the segmental baffle with different percentage of cot ranging from 15% to 40%. Also having a single tube pass and single shell pass with parallel flow arrangement was considered. It shows heat transfer rates for shell and tube heat exchanger for different percentage of baffle cut. It noticed the variation in rate of heat transfer for 20% and 30% were minimum.

III. CONCLUSIONS

To achieving maximum efficiency of heat exchanger many researcher have situate their effort to maximize the performance along with reduced cost. From the literature review it can be conclude that,

- It was observed that the Kern method always under predicts the heat transfer coefficient.
- For properly spaced baffles, it was observed that the CFD simulation results are in very good agreement with the Bell-Delaware results. The results were also sensitive to the baffle cut selection.
- There was increase in pressure drop with increase in fluid flow rate in shell and tube heat exchanger which increases pumping power.
- The flow structures that were visualized using the CFD simulations showed that for the smaller number of baffles, the cross flow windows were not well utilized and some recirculation regions form behind the baffles.
- The shell side fluid flow had been governed by the baffle geometry and the shell side heat transfer coefficient was also affected by the baffle geometry.
- The Nusselt number had inverse relationship with baffle spacing. The decrease of baffle spacing causes the increase of Nusselt number over tubes, so OHTC increases.
- To increase of baffle spacing, $U/\Delta p$ ratio increases because pressure drop rapidly decreases, but the decrease of OHTC is lower than the decrease of pressure drop.
- In the near future, improvements in the computer technology will make full CFD simulations of much larger shell-and-tube heat exchangers possible.
- The simulation was better option in the optimization of baffle geometry for effective shell side pressure drop utilization along with the shell side heat transfer co-efficient.

REFERENCE

[1] Ender Ozden, Ilker Tari “Shell side CFD analysis of a small shell-and-tube heat exchanger”, Energy Conversion and Management, Vol. 51, No. 5, pp. 1004-1014, 2010

[2] Gabriel Batalha Leoni, “Assessment with computational fluid dynamics of the effects of baffle clearances on the shell side flow in a shell and tube heat exchanger”, Applied Thermal Engineering, 112, 497–506, 2017.

[3] Chetan Namdeo Patil N. S. Bhalkikar, “CFD Analysis of Shell and Tube Heat Exchanger to Study the Effect of Baffle Cut on the Pressure Drop and Heat Transfer Coefficient”, International Journal for Scientific Research & Development, Vol. 2, Issue 05, ISSN (online): 2321-0613, 2014.

[4] Ali Falavand Jozaei, Alireza Baheri, Mariam K. Hafshejani and Armin Arad, “Optimization of Baffle Spacing on Heat Transfer, Pressure Drop and Estimated Price in a Shell-and-Tube Heat Exchanger”; World Applied Sciences Journal, 18 (12): 1727-1736, 2012, ISSN 1818-4952.

[5] Yusuf Ali Kara, Ozbilen Guraras, “A computer program for designing of Shell and tube heat exchanger”, Applied Thermal Engineering; 24, 1797–1805, 2004.

[6] W. ROETZEL and D. LEE, “Experimental investigation of leakage in shell-and-tube heat exchangers with segmental baffles”, Int. J. Heat Mass Transfer; 1993; Vol.3 6, No. 15, pp.3765-3771

[7] Rajagapal Thundil Karuppa Raj and Srikanth Ganne, “Shell Side Numerical Analysis Of A Shell And Tube Heat Exchanger Considering The Effects Of Baffle Inclination Angle On Fluid Flow”, Thermal Science; Vol. 16, No. 4, pp. 1165-1174, 2012.

[8] Emerson Hochsteiner de Vasconcelos Segundo, “Economic optimization design for shell-and-tube heat exchangers by a Tsallis differential evolution”, Applied Thermal Engineering, 111 (2017), 143–151

[9] S.M. Shahril, G.A. Quadir, N.A.M. Amin, Irfan Anjum Badruddin, "Thermo hydraulic performance analysis of a shell-and-double concentric tube heat exchanger using CFD", International Journal of Heat and Mass Transfer, 105 (2017), 781–798

[10] Kiran K, A M Mulla, Manoj and Umesh C J, "Investigation of baffle spacing effect on shell side heat transfer characteristics in shell and tube heat exchanger using computational fluid dynamics", Thermal Engg. 73 (2014), 26022-26026.

[11] Kirubadurai.B, R.Rajasekaran, K.Kanagaraj, P.Selvan, "Heat Transfer Enhancement of Shell and Tube Heat Exchanger", International Journal for Research In Applied Science and Engineering Technology (IJRASET), Vol. 2 Issue VIII, August 2014, ISSN: 2321-9653.

[12] Prasanna. J, H. R. Purushothama, Devaraj K, Murugeshan, "A Numerical Analysis of Hydrodynamic and Heat Transfer Effects of Shell-And-Tube Heat Exchanger for Different Baffle Space and Cut", Vol. 2, No. 4, ISSN: 2320-2491, June-July 2013.

[13] Dogan Eryener, "Thermoeconomic optimization of baffle spacing for shell and tube heat exchangers", Energy Conversion and Management 1478–1489, (2006)

[14] Durgesh Bhatt, "Shell and Tube Heat Exchanger Performance Analysis", International Journal of Science and Research, 2319-7064, 2012

[15] S.M. Shahril, "Thermo hydraulic performance analysis of a shell-and-double concentric tube heat exchanger using CFD", 105 (2017) 781–798

[16] Devanand D Chillal, "Effects on heat transfer rate for shell side in tema e-type shell and tube heat exchangers due to variation in the baffle cut percentage using CFD software", International Journal of World Research, Vol: I Issue XXXVII, January 2017

