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HEAT TRANSFER ANALYSIS OF A SHELL AND TUBE HEAT EXCHANGER WITH BAFFLE EFFECT USING KERN METHOD

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ABSTRACT

In current days, Shell and Tube Heat Exchanger is the most well-known type heat exchanger generally utilized as a part of oil refinery and other substantial synthetic procedure, in view of its higher Heat Transfer capacity. In the present study, comparatively analysis of heat transfer coefficient in shell and tube heat exchanger (STHE), as a air used in fluid. To study and analyze the effect of baffles and baffle inclination at different positions in same mass flow rates. The thermal analysis is done by taking the hot air inside the shell and cold air inside the tubes. The design of shell and tube heat exchanger using kern method for air is validated by Donoque correlations for shell tube side.

KEYWORDS: Shell and Tube Heat Exchanger, Heat Transfer, Thermal analysis, Donoque correlations

I. INTRODUCTION

Heat exchangers are one of the generally used equipment in the process industries. Heat exchangers are utilized to exchange heat among two procedure streams. One can understand their use that any procedure which includes cooling, warming, boiling, condensation or evaporation will oblige a heat exchanger for these reasons. Process liquids, more often than not are warmed or cooled before the procedure or experience a stage change. Distinctive heat exchangers are named by application. For instance, heat exchangers being utilized to consolidate is known as condensers, likewise warm exchanger for bubbling reasons for existing are called boilers. Presentation and effectiveness of Heat exchangers are measured through the measure of Heat exchange utilizing minimum territory of Heat exchange and weight drop. A superior presentation of its effectiveness is finished by figuring over all Heat exchange coefficient. Weight fall and range required for a specific measure of Heat exchange, gives knowledge about the capital cost and power prerequisites (administration expense) of a Heat exchanger. Ordinarily, there is heaps of writing and speculations to plan a Heat exchanger as per the necessities

II. LITERATURE REVIEW

Manoj Kumar Pandita et al {1} Heat transfer analysis of a single shell and single tube heat exchanger with baffles inclined at different angles using kern method. To investigate the effect of various baffle inclination angles on the heat transfer characteristics namely -45°, 0° and 45° for Shell and Tube Heat Exchanger on the basis of theoretical calculations. The arrangement of all the three baffles with respect to fluid flow will be as follows:-

(a) -45° baffle will be inclined and opposite to the fluid flow
(b) -0° baffle will be perpendicular to the fluid flow
(c)+ 45° baffle will be inclined and in direction to the fluid flow Thus any inclination of the baffles in the positive direction will increase the heat transfer and any angle or inclination in the negative direction will reduce the heat flux

Jian-Fei Zhang et al {2} A design and rating method of heat exchanger with helical baffles. It is changed to segmental baffle to helical baffle for common shell. The segmental baffles given the pressure drop and heat transfer capacity to be very less with enlarging baffle cut length to found maximum possible pressure drop. But used the helical baffle in place of segmental baffle decreases the pressure drop much too much and fixed flow rate the heat transfer coefficient per unit pressure drop of helical baffle is higher to segmental baffle. These are given to four different cases for using of helical baffle is better performance as compared to segmental baffle.

(a) Case 1 the comparative calculation of segmental baffle and helical baffle by using the tube core 40 degree middle 0verlapped the helical baffle given 39% of pressure drop to its unit with 16% decrease heat transfer area given better performance as compared to segmental baffle.

(b) Case 2 the comparative calculation of helical baffle using tube core 40 degree middle overlapped 46% of pressure drop as compared to segmental baffle and 13% reduced heat transfer area.

(c) Case 3 these are shown the result the helical baffle 40 degree middle overlapped to given 33% reduced heat transfer area to original segmental baffle.

(d) Case 4 in this case used helical baffle 20 degree middle overlapped pressure drop is 33% with 10% decrease heat transfer area as compare to segmental baffle.

Sunil S. Snide et al. {3} has studied to increase the performance of single phase tubular heat exchanger used continuous helical baffle as compared to segmental baffle. In this type of heat exchanger used of helical baffle reducing the pressure drop in shell side, weight, pumping cost and fouling factor as compared to segmental baffle. In helix angle type of heat exchanger used in any plant , industries etc saving capital cost as well as operating and maintenance cost thus increases the reliability and availability of the process plant in cost of effective way. In tabular type heat exchanger using of helical baffle the ratio of heat transfer coefficient to pressure drop are higher than as compared to segmental baffle. It means the uses of helical baffle the heat transfer coefficient are higher as compare to conventional segmental baffle for consuming same pumping power. It can be shown the result proper baffle inclination give the better performance of heat exchanger.

Hamidou Benzenine et al {4} has study numerically a tumultuous flow of air through rectangular section. In this study two baffles were introduced to produce vortices, to get better result of mixture. Numerical results obtained by finite volume method to analyse dynamic behaviour of tumultuous flow with the help of Reynolds number model. The highest disturbance found upstream 2nd baffle which showed that wave of baffles induced with development on the skin fiction of 9.91% in case of α=15°,more than 16%in other cases.

In relation to the pressure loss wave of baffles was insured improvements from 10.43% in all cases compared with baffles of plane. This investigation was carried for four cases of slopes for uneven baffles from 00 to 450, with step equal 15. The finally result that vertical use of purely waved baffles in study increase the performance of heat exchanger.

Kevin M. Lunsford et al. {5} has analysis to enhance performance of heat exchanger through a used of different conditions. If the initial operating condition of exchanger is correctly in first step. Then next step considering raises pressure drop of the exchanger with single phase heat transfer, then increased the velocity of fluid then higher heat transfer coefficient. If we can used another condition to estimated fouling factors should be considered. If periodic cleaning and less conservative fouling factors. It is final condition to enhanced heat transfer through the use of finned tubes and modified baffles.

Jaykumar and Grover et al. {6} studied residua heat removal system used in helically coiled heat exchanger for different types of parameters. Jay kumar et al. (2002) had again extended the work to find out stability of operation in this system when it is mounted is moving.

Prasanna. J et al. {7} numerical analysis of heat transfer and hydrodynamic effects of shell and tube heat exchanger using different baffles cut and space. CFD analysis of shell side in small shell & tube heat exchanger modelled with sufficient detail to solve temperature and flow. From CFD simulation results in shell side heat transfer coefficient. Pressure drop and heat transfer values obtained for the fixed tube wall and shell side temperature. By changing baffle spacing between shell 6 and 12, and baffle cut values of 36%and25% for flow rate of fluid in shell side 0.5, 1 and 2kg/s then simulation results compared with Kern and Bell-Delaware methods.

It is know that Kern method get heat transfer coefficient under predictions. For proper baffle spacing it is find CFD simulation results are very good with Bell Delaware method. Most of the cases surprising the difference between Bell-Delaware method and CFD prediction of the heat transfer rate less1% for most cases. It is confirm Bell-Delaware method is very good in heat exchanger industry and show the power techniques in CFD as a design of heat exchangers.

III. Theoretical Calculation by Kern Method

CALCULATION FOR SIX BAFFLES ARE USED

Shell Diameter = 230 mm

Shell Thickness =6 mm

Tubes outer diameter = 16mm

Tubes inner diameter = 13 mm

Length = 550mm

Evaluating h_o using **DONOHUE** correlation McCabe et. al,

$$h_o D_o/k = 0.2*(D_o G_e/\mu)^{0.6} * (c_p \mu/k)^{0.3} * (\mu/\mu_w)^{0.14}$$

Physical Properties are found at $T_{Avg.}=(T_{in\ air} + T_{out\ air})/2$

$G_e = (G_b * G_c)^{0.5}$

$G_b = M_{water}/S_b$ & $G_c = M_{water}/S_c$

$S_b = f_b*\pi*D_s^2/4 - N_b*\pi*D_o^2/4$

F_b = fraction of the cross sectional area of the shell occupied by baffle window; consider it 0.1995

D_s = Diameter of the shell

N_b = No. of tubes

D_o = Outside diameter of tube

$S_c = PD_s (1- D_o/P)$

P = Tube pitch= center to center distance between tubes = 1.25 D_o

If μ/μ_w is assumed to be 1,

Case-I

$T_1 = 386^0$ C

$T_2 = 50^0$ C

$T_{avg.} = (T_1 + T_2)/2$

$= (386+50)/2$

$= 218^0$C

Physical Properties of dry & saturated air at this Temperature

K = 38.954* $10^{\wedge 3}$ W/m ^{0}C

μ = 26.466*$10^{\wedge 6}$ kg/m-s

C_p= 1. 02824 kj/kg ^{0}C

Mass Flow Rate m = 0.0280kg/s

$G_b = m/S_b$ $S_b = f_b*\pi*D_s/4 - N_b*\pi*D_o/4$

$G_b = 4.48$

$G_c = m/S_c$ $S_c = PD_s (1- D_o/P)$

$G_c = 30.43$

$G_e = (G_b*G_c)^{0.5}$

$G_e = 11.67$

Now Using Donoque Equation for shell side

$h_s = 15.36$ W/m^{2} ^{0}C

Case-II

$T_1 = 386^0$ C

$T_2 = 68^0$ C

$T_{avg.} = (T_1 + T_2)/2$

$= (386+68)/2$

$= 227^0$C

Physical Properties of dry & saturated air at this Temperature

K = 39.521* $10^{\wedge 3}$ W/m ^{0}C

μ = 26.799*$10^{\wedge 6}$ kg/m-s

C_p= 1.02993 kj/kg ^{0}C

Mass Flow Rate m = 0.0280kg/s

$G_b = m/S_b$ $S_b = f_b*\pi*D_s/4 - N_b*\pi*D_o/4$

$G_b = 4.29$

$G_c = m/S_c$ $S_c = PD_s (1- D_o/P)$

$G_c = 30.43$

$G_e = (G_b*G_c)^{0.5}$

$G_e = 11.42$

Now Using Donoque Equation for shell side

$h_s = 15.27$ W/m^{2} ^{0}C

Case-III

$T_1 = 400^0$ C

$T_2 = 100^0$ C

$T_{avg.} = (T_1 + T_2)/2$

$= (400+100)/2$

$= 250^0$C

Physical Properties of dry & saturated air at this Temperature

K = 40.95* $10^{\wedge 3}$ W/m ^{0}C

μ = 27.64*$10^{\wedge 6}$ kg/m-s

C_p= 1.0344 kj/kg ^{0}C

Mass Flow Rate m = 0.0280kg/s

$G_b = m/S_b$ $S_b = f_b*\pi*D_s/4 - N_b*\pi*D_o/4$

$G_b = 4.29$

$G_c = m/S_c \quad S_c = PD_s (1- D_o/P)$

$G_c = 30.43$

$G_e = (G_b * G_c)^{0.5}$

$G_e = 11.43$

Now Using Donoque Equation for shell side

$h_s = 15.58\ W/m^2\ ^0C$

IV. RESULT & CONCLUSION

Thus a comparison of the results from calculations and from analysis with the help of Kern Method is presented below:

S.No.	*Case*	*Heat Transfer Coefficient Shell Side in $W/m^2\ ^\circ C$*
1.	*I*	*15.27*
2.	*II*	*15.36*
3.	*III*	*15.58*

V. CONCLUSION

Recent years, heat exchanger is often used for the request of knowledge. But the relevant design is not provided by the actual standards. This work presents the improvements to the Kern method for the shell and tube heat exchanger. It is found that among the all method, the Kern technique gave a straightforward strategy to calculate heat transfer coefficient. By this experimentation it is clear that heat transfer coefficient and different heat parameters can be calculated and analyzed up to higher accuracy as compared to the other methods. After this project it is to be said that the shell and tube heat exchanger has been given the considerable respect among all the classes of heat exchanger because of their more like relatively huge proportions of heat exchange region to volume and weight and some more. In addition very much outlined techniques are accessible for its planning and examination.

From the above analysis we have found that when the baffles are present the pressure drop is more than in the case when there are no baffles. Also the heat transfer is more in case when the baffles are present. This is evident from the thermal plots of both the cases of heat exchanger with baffles and without baffles. A higher temperature difference is attained in the case when the baffles are present.

REFERENCES

[1] Manoj Kumar Pandita et al Heat transfer analysis of a single shell and single tube heat exchanger with baffles inclined at different angles using kern method.

[2] Jian-Fei Zhang, Ya-Ling He and Wen-Quan Tao A Design and Rating Method for Shell-and-Tube Heat Exchangers With Helical Baffles.

[3] Prof. Sunil S. Shinde et al. Numerical comparison on Shell side performance of Helixchanger with center tube with different helix angles. Volume 3, Issue 8, August 2013 ISSN 2250-3153

[4] Hamidou Benzenine, Rachid Saim , Said Abboudi and Omar Imine, "Numerical analysis of a turbulent flow in a channel provided with transversal waved baffles", International Journal of thermal science, Vol. No. 17, pp. 1491-1499, 2012.

[5] Kevin M. Lunsford et al. has analysis to enhance performance of heat exchanger through a used of different conditions.

[6] Jayakuma , J.S. and Grover , R.B.,1997 , Two phase natural circulation residual heat removal , In Proc 3rd ISHMT-ASME Heat and Mass Transfer Conference, Kanpur India.

[7] Prashanta Dutta and Akram Hossain, "Internal cooling augmentation in rectangular channel using two inclined baffles", International Journal of heat and fluid flow, Vol. 26, pp. 223- 232, 2005.

[8] E.J.J. van der Zijden et al Embaffle heat exchanger in fouling operation. International Conference on heat exchanger fouling and cleaning-2013 June0914, 2013 Budapest Hungary.

[9] M.A. Mehrabian et al. "The overall heat transfer characteristics of a double pipe heat exchanger: comparison of experimental data with predictions of standard correlations" Archive of SID Vol. No. 15, pp.395-406,2002.

[10] Joemer.C.S et al. Optimization of Shell & Tube Heat Exchanger by Baffle Inclination & Baffle Cut. ISSN (Online) : 2319 - 8753

[11] Hardik Tandel et al. Effect of Baffle Geometry on Shell and Tube Heat Exchanger-A Review. Vol. 2, Issue 11, 2015 | ISSN (online): 2321-0613

[12] V. Vedhagiri Eswaran1, et al. design and numerical enhancement analysis of slanting type baffle plate in shell and tube heat exchanger. vol. 10, no. 8, may 2015 issn 1819-6608

[13] Praveen Kumar Jha et al. Analytical Performance Analysis of Shell and Tube Heat Exchanger by Varying Number of Baffles and Mass Flow Rate. Vol. 3, Issue 04, 2015 | ISSN (online): 2321-0613