Sonu Kumar, 2021, 9:6
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Thermal Analysis of Shell and Tube Heat Exchanger with Different Design of Baffle Plate

M. Tech Scholar Sonu Kumar, Prof. Neetesh Gupta
Department of Mechanical Engineering,
BITS, Bhopal, MP, India

Abstract- Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. The basic configuration of shell and tube heat exchangers, the thermal analysis and design of such exchangers form an included part of the mechanical, thermal, chemical engineering scholars for their curriculum and research activity.

Keywords- Shell and Tube Heat Exchanger, baffle, design, thermal analysis.

I. INTRODUCTION

Heat exchangers are also used to transfer heat between two fluids that would be at various temperatures along a solid surface. The nonlinear dynamics of this process, notably the varying steady-state gain or time constant them with process fluid [1], make it complicated.

The shell-and-tube heat exchanger is the most popular form of heat exchanger, with uses in refrigeration, power production, heating, air conditioning, chemical processes, manufacturing, and medicine [2]. It really is made up of a bundle of tubes contained in a cylindrical shell, including one fluid flowing thru the tube and another running between both the tubes as well as the shell. A heat exchanger may be defined as a device that transmits thermal energy between two or more fluids of varying temperatures. Several industrial processes would indeed be impossible to complete without this equipment. Refrigeration, air conditioning, and chemical plants all use heat exchangers. It's utilised for a variety of things, including transferring heat from a hot to a cold fluid. They're commonly employed in a variety of industrial settings. Researchers had worked

The velocity and temperature contour fields upon that shell side, on the other hand, are much more complicated, and their performance is influenced by baffle elements such as their arrangement the spacing scheme.

Round tubes were put in cylindrical shells having their axes aligned with the shell axis to create this. Shell side refers to the region surrounding the tubes, whereas tube side refers to the inside tubes. The primary function of baffles would be to produce turbulence, which increases the convective heat transfer coefficient of the shell side fluid.

The following methods are used to evaluate the performance of the heat exchanger: I Outlet temperature of the hot stream (Tho) profile, ii) Approach temperature (Tho - Tci) profile, iii) Log Mean Temperature Difference (LMTD) with time, iv) Heat load profile, and v) Time series of overall heat transfer coefficient. The first four approaches are commonly utilised, however they are poor at distinguishing the net effect of fouling of process disturbances.

The total heat transfer coefficient technique, on the other hand, necessitates comprehensive

International Journal of Science, Engineering and Technology

An Open Access Journal

computations and knowledge of the exchanger shape [3]. Fouling causes the heat exchanger's performance to decrease over time. It tends to rise with time, with a particularly site-specific trajectory. As both a result, a predictive model of evaluating heat exchanger performance is required.

II. RESEARCH METHODOLOGY

The design and prediction of heat exchanger behaviour are too complicated to mathematically mode land solve using analytical solution. Closed form solutions are available only in situations where the model has several simplifying assumptions (Gvozdenac and Mitrovic, 2012). Heat exchanger design based on these assumptions has errors that make the prediction of thermal behavior challenging. The design challenges are multiple objectives with several constraints to be fulfilled simultaneously.

In this study shell and tube heat exchanger with 10 different baffles are placed along the shell in alternating orientations with cut facing up, cut facing down, etc., in order to create flow paths across tube bundle. The geometric modelling is done using CAD software called CATIA V5R21 because it is easy to model Heat exchanger in 3D modelling software.

A STHX with different baffle geometries is designed [15, 16, and 17] to study the effects of variations in baffle geometry. A water-water shell and tube heat exchanger is designed considering the data in the following table 1.

Table 1. Dimensions of the shell side and tube side of the heat exchanger.

Specification	Dimensions
Length of heat exchanger , L	610 mm
Shell outer diameter, DS	160 mm
Tube length, l	610 mm
Tube outer diameter, do	16 mm
No. of tubes, Nt	21
Baffle spacing, ΔBt	100 mm
Baffles thickness, t	2.5 mm
No. of baffles Nb	10

1. Geometry Modeling:

First the geometry of the model is created in CATIA V5R21. The model is saved in IGS. format. The external geometry file is imported in the design modeller of the ANSYS fluent. The geometry has totally 22 parts. One shell and 21 tubes bundle.

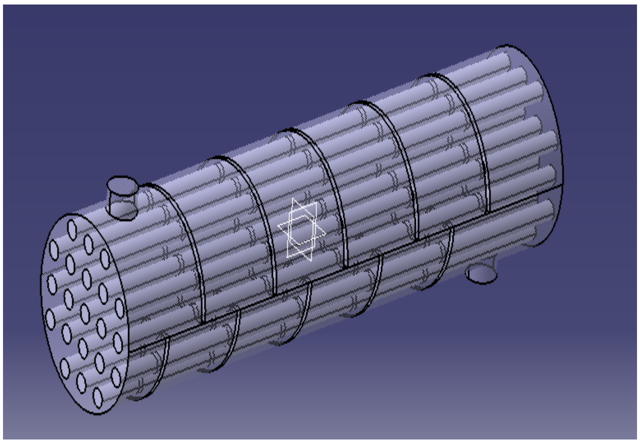

Fig 1. Geometry of the model.

III. RESULTS AND DISCUSSION

1. Pressure Variations with Single Segmental Baffle Configurations in STHX:

In order to better explain this situation, it must be noted that lower mean velocity gives lower velocity gradient among the fluids and channel walls, which in turn reduces the wall shear stress. The reduced friction results in lower pressure difference required to move the fluid along the channels, which is indicated by the pressure drop values.

Pressure drop is depends on many factors such as viscosity, geometry etc. In segmental heat exchanger fluid is settled in between the baffle, so pressure drop is increased. Pressure Distribution across the shell and tube heat exchanger is given below in Fig. 2. Pressures vary largely from inlet to outlet. The contours of static pressure are shown in the entire figure to give a detail idea.

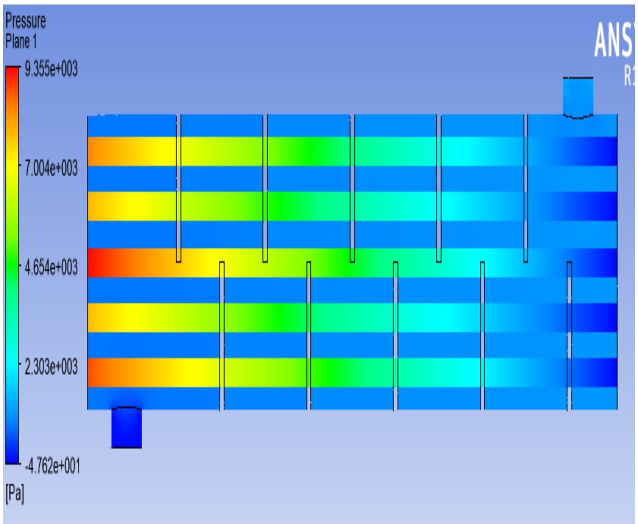

Fig 2. Pressure variations in STHX with single segmental baffles.

2. Velocity Variations:

From figure 3, it is inferred that single segmental baffles enhance the heat transfer as they guide the shell side fluid to flow in a zigzag pattern between the tube bundle, which enhances the turbulence intensity and the local mixing. However, the single segmental baffles have some inherent defects since the structure limitations, such as fouling in the stagnation zone near the shell wall and the rear of baffle plates, significant bypass streams and leakage streams due to manufacturing tolerances and short operational lifetime as a result of flow induced tube vibration.

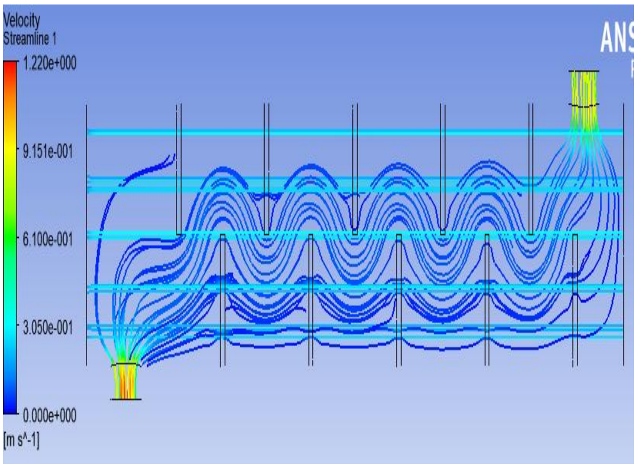

Fig 3. Velocity variations in STHX with single segmental baffles.

IV. CONCLUSIONS

CFD simulation studies on Shell and Tube Heat Exchanger has been carried with single, flower 'A' type, and flower 'B' type baffle configurations.

The following are the conclusions arrived from these simulation studies:

- Single Segmental Baffles provide good heat transfer coefficient but with large pressure drop and thus consume large pumping power.
- Flower Baffles are the most effective baffles as they reduce the pressure drop by 46 % - 51 % while the heat transfer coefficient is lowered to 13 % -21 % of that produced with single segmental baffles.
- The slope of the curves is generally found to decrease with increase in shell side mass flow rate. Single segmental baffles show the highest heat transfer coefficient while 'A' and 'B' baffles show slowest heat transfer coefficient.
- 'B' Baffles are more effective than 'A' Baffles as they reduce the Pressure Drop to the same extent as that of 'A' baffles but with a better thermal performance associated.

REFERENCES

[1] L.V. Kamble, D.R. Pangavhane, T.P. Singh (2014), Heat Transfer Studies using Artificial Neural Network - A Review, International Energy Journal. 14, 25-42.

[2] Kwang-Tzu Yang (2008), Artificial Neural Networks (ANNs): A New Paradigm for Thermal Science and Engineering, Journal of Heat Transfer, 130(9), 112-120.

[3] Singh D.V., Maheshwari G, Shrivastav R., Mishra D. K., (2011), Neural network– comparing the performances of the training functions for predicting the value of specific heat of refrigerant in vapour absorption refrigeration system, International Journal of Computer Applications, 18(4): 1-5.

[4] Gerardo Diaz, Mihir Sen, K.T. Yang, Rodney L. McClain (2001), Dynamic prediction and control of heat exchangers using artificial neural networks, International Journal of Heat and Mass Transfer, 44, 1671-1679.

[5] Ahilan C, Kumanan S, Sivakumaran N (2011), Prediction of Shell and Tube Heat Exchanger Performance using Artificial Neural Networks, Proceeding of the International Conference on Advanced Computing and Communication Technologies, 307-312.

[6] Hisham Hassan Jasim (2013), Estimated Outlet Temperatures in Shell-and-Tube Heat Exchanger Using Artificial Neural Network Approach Based on Practical Data, Al-Khwarizmi Engineering Journal, 9(2), 12- 20.

[7] Govind Maheshwari (2018), To Evaluate the Performance of Heat Exchanger through Artificial Neural Networks Approach, International Journal Of Core Engineering & Management, 5(3), 21-31.

[8] A.A Shrikant (2016), CFD simulation study of shell and tube heat exchangers with different baffle segment configurations, Applied Thermal Engineering, 1-29.

[9] Nader Jamali SoufiAmlashi (2013), Nonlinear System Identification of Laboratory Heat Exchanger Using Artificial Neural Network Model, International Journal of Electrical and Computer Engineering, 3(1), 118-128.

[10] Mahdi Jalili Kharaajoo (2004), Neural network based predictive control of a heat exchanger nonlinear process. Journal of Electrical and Electronics Engineering 4:1219–1226.

[11] A.R. Moghadassi (2011), An Expert Model For The Shell And Tube Heat Exchangers Analysis By Artificial Neural Networks, ARPN Journal of Engineering and Applied Sciences, 6(9), 78-93.

[12] M.Thirumarimurugan (2009), Simulation Studies on Plate Type Heat Exchanger using ANN, International Journal of ChemTech Research, 1(2), 349-354.

[13] Anurag Kumraa, Nikhil Rawal, Pijush Samui (2013), Prediction of heat transfer rate of a Wire-on-Tube type heat exchanger: An Artificial Intelligence approach, International Conference on Design and Manufacturing, ICONDM 2013, 11-22.

[14] Tan C.K., Ward J., Wilcox S.J., Payne R., 2009. Artificial neural network modeling of the thermal performance of a compact heat exchanger. Applied Thermal Engineering 29: 3609-3617.

[15] Sahoo A. and G.K. Roy. 2007. Artificial neural network approach to segregation characteristic of binary homogeneous mixtures in promoted gas solid fluidized beds. Journal of Powder Technology 171 (1): 54-62.

[16] Shah R.K., 1985. Compact Heat Exchangers. Handbook of Heat Transfer Applications, 2nd ed., W. M. Rohsenow, J. P. Hartnett, and E. N. Garnic, eds., McGraw-Hill, New York, NY, pp. 4-174–4-312.