ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Performance of Shell and Tube Heat Exchanger under Varied Operating Conditions

N. Prabhu Kishore[1], N. Alekhya[2], J. Ugandhar [3]

Asst. Professor, Department of Mechanical Engineering, MLR Institute of Technology, Hyderabad, Telangana, India[1]

Asst. Professor, Department of Aeronautical Engineering, MLR Institute of Technology, Hyderabad, Telangana, India[2]

U.G. Student, Department of Mechanical Engineering, MLR Institute of Technology, Hyderabad, Telangana, India[3]

ABSTRACT: A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, at different temperatures. The problem involved in this is that performance of the heat exchanger changes with the change in the constructional parameters. The design of a shell-and-tube heat exchanger usually involves a trial and error procedure with combination of the design variables in order to calculate the heat transfer coefficient. The trial and error procedure is taken to check if there is any possibility of increasing the heat transfer coefficient. Since several discrete combinations of the design configurations are possible, the designer needs an efficient strategy to quickly locate the design configuration having the minimum heat exchanger cost. In this paper the tube metallurgy and baffle spacing are being changed to obtain the heat transfer coefficient. The results obtained from this experiment are compared to find the effectiveness.

KEYWORDS: Heat exchanger, Shell and tube, heat transfer coefficient, baffle spacing.

I. INTRODUCTION

A shell and tube heat exchanger is a class of heat exchanger designs. It is most common type of heat exchanger used in oil refineries and other large chemical processes and is suited for higher pressure applications. This type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid run-through the tubes and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids.

The use of heat exchangers is extensive in power plants, refrigeration & air-conditioning systems, Space Chemical, Nuclear, Petrochemical, and Cryogenic industries. Heat exchangers appear in variety of shapes and sizes It can be as huge as a power plant condenser transferring hundreds of Megawatts of heat or as tiny as an electronic chip cooler which transfers only a few Watts of thermal energy.

Heat exchangers are one of the equipment mostly used in the process industries. Heat exchangers are mainly used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger. Process fluids, usually are heated or cooled before the process or undergo a phase change. Different heat exchangers are named according to their application. For example, heat exchangers being used to condense are known as condensers similarly, heat exchanger for boiling purposes are called boilers. Performance and efficiency of heat exchangers are measured through the amount of heat transfer using least area of heat transfer and pressure drop. A more better presentation of its efficiency is done by calculating over all heat transfer coefficient. Pressure drop and area required for a certain amount of heat transfer, provides an insight about the capital cost and power requirements (Running cost) of a heat exchanger. There is lot of literature and theories to design a heat exchanger according to the requirements.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

II. SPECIFICATIONS OF HEAT EXCHANGER

The heat exchanger used in this paper is made with one shell, 7 tubes and 4 baffles. The shell and tubes are made with stainless steel 304 material. Two motors are used to supply the power to pump the water into the heat exchanger. The specifications of the heat exchanger built for this experiment are given in the below table1.

Heat exchanger length, L	600mm
Shell inner diameter, Di	90mm
Tube outer diameter, Do	20mm
Number of tubes, Nt	7
Number of baffles, Nb	4
Motors	2
Type of Material	SS METAL 304

Table1:Specifications of Heat Exchanger

III. ACTUAL PROCESS AND PROCEDURE

In any heat exchanger there must be a fluid that requires a change in energy (heating or cooling) and a fluid that can provide that energy change. One fluid is sent through a pipe on the inside of the heat exchanger while the other fluid is sent through a pipe on the outside. In this configuration, no mixing of the hot and cold fluids needs to take place. This is very convenient for many processes, especially when product purity needs to be ensured. This arrangement also allows for large quantities of heat to be transferred quickly and it is relatively easy to maintain consistent operating conditions.

There are three principle means of achieving heat transfer, conduction, convection, and radiation. Heat exchangers run on the principles of convective and conductive heat transfer. Radiation does occur in any process. However, in most heat exchangers the amount of contribution from radiation is miniscule in comparison to that of convection and conduction. Conduction occurs as the heat from the hot fluid passes through the inner pipe wall. To maximize the heat transfer, the inner-pipe wall should be thin and very conductive. However, the biggest contribution to heat transfer is made through convection.

There are two forms of convection natural and forced convection. Natural convection is based on the driving force of density, which is a slight function of temperature. As the temperature of most fluids is increased, the density decreases slightly. Hot fluids therefore have a tendency to rise, displacing the colder fluid surrounding it. This creates the natural “convection currents” which drive everything from the weather to boiling water on the stove. Forced convection uses a driving force based on an outside source such as gravity, pumps or fans. Forced convection is much more efficient, as they are often turbulent. Turbulent flows undergo a great deal of mixing which allow the heat to be transferred more quickly.

In this paper water is used as both the hot and cold fluid. The purpose of this heat exchanger is to cool a hot stream. Cooling water is sent through the shell and hot water is sent through the tubes. Heat transfer occurs in both directions the hot water is cooled and the cooling water is heated. This arrangement is called a “shell-and-tube” heat exchanger. To increase the heat transfer rate in shell and tube type heat exchanger, the segmental baffles are introduced inside the cover pipe. There are many other forms of heat exchangers most notably the double-pipe heat exchanger. The

IJIRSET

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

flow arrangement used in analysis is laminar counter flow as it is more efficient than parallel flow arrangement . The different orientations of baffles in heat exchanger are given in Figure 1

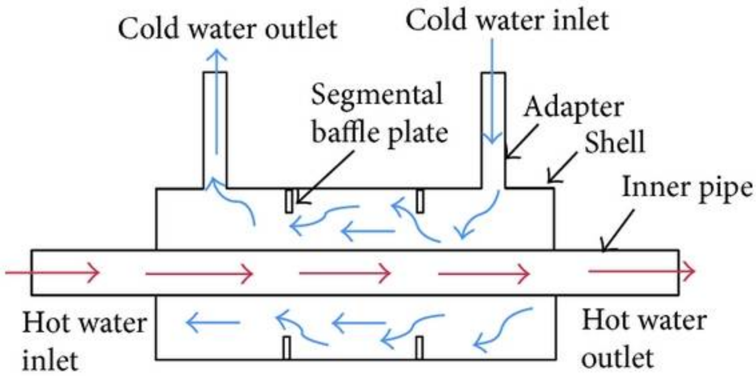

Fig1: Orientation of Baffles in heat exchanger

IV. DESIGN OF HEAT EXCHANGER

The figure 2 below shows the baffle spacing given for shell inside diameter. Higher baffle spacing may lead to predominantly longitudinal flow, which is less efficient. The cross-flow and large unsupported tube spans make the exchanger prone to tube failure due to flow-induced vibration. For turbulent flow on the shell side (Re > 1,000), the heat-transfer coefficient varies to the 0.6–0.7 power of velocity; however, pressure drop varies to the 1.7–2.0 power. For laminar flow (Re < 100), the exponents are 0.33 for the heat transfer coefficient and 1.0 for pressure drop. Thus as baffle spacing is reduced, pressure drop increases at a much faster rate than does the heat-transfer coefficient. So the will be an optimum ratio of baffle spacing to shell inside diameter that will result in the highest efficiency of conversion of pressure drop to heat transfer. This optimum ratio used is normally between 0.3 and 0.6.

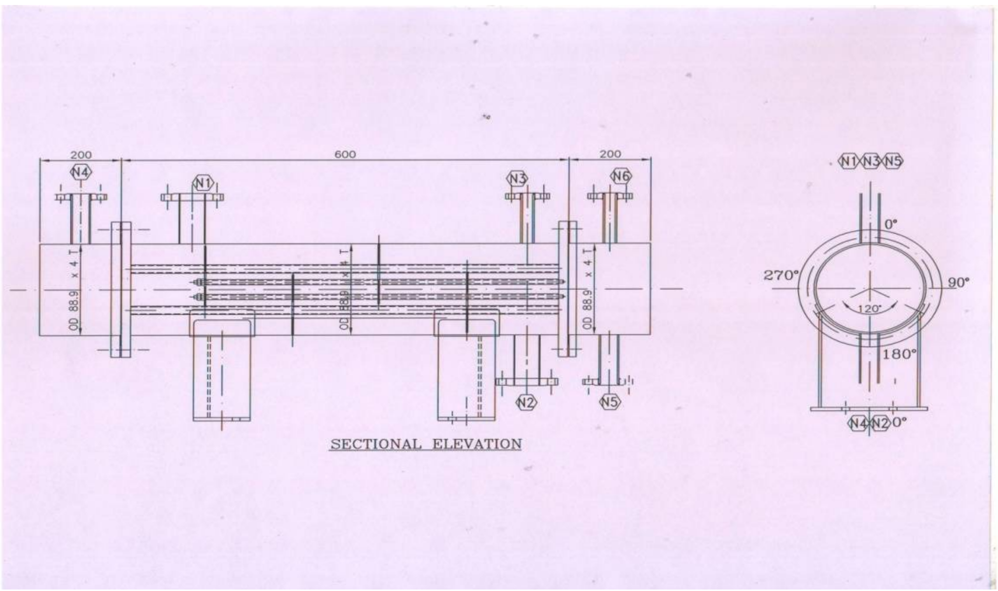

Fig2: Configuration layout of the shell and tube heat exchanger

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

IV. EXPERIMENTAL SETUP OF HEAT EXCHANGER

The heat exchanger used for the experiment is shown in the figure 3. In this experiment two different cases were taken into considerations to find effectiveness. The first experiment was done by sending the hot water through the shell and cold water through the tubes. The second one was done by sending the cold water through the shell and the hot water through the tubes.

Fig 3: Experimental Setup

V. RESULTS AND DISCUSSIONS

In this paper, we assume that negligible heat transfer between the system and its surroundings, negligible potential or kinetic energy changes, constant specific heats, and that the fluids are not undergoing any phase change. Considering these parameters the two cases are experimented in the setup. The table2 given below shows the values obtained from the experiment flowing hot water inn shell and cold water flowing in the tube.

S. No	Hot water inlet(thi)(^{0}C)	Hot water oulet(tho) (^{0}C)	Cold water inlet(tci) (^{0}C)	Cold water oulet(tco) (^{0}C)	Degree of cooling (thi-tho)	Degree of heating (tci-tco)	Effectiveness of heat exchanger
1.	44	35	28	33	9	5	0.172
2.	43	34	28	34	9	6	0.171
3.	43	34	28	34	9	6	.168
4.	42	33	28	33	9	6	0.167
5.	42	33	28	34	9	6	0.166
6.	42	30	28	32	9	4	0.156
7.	42	30	28	32	9	4	0.155

Table2:Hot water flowing in shell and cold water flowing in the tube

The table3 given below shows the results obtained from the experiment flowing hot water in tubes and cold water flowing in the shell. The effectiveness of heat exchanger is more when hot water sent through tubes and cold water through shell.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

S. No	Hot water inlet(thi)(^{0}C)	Hot water oulet(tho) (^{0}C)	Cold water inlet(tci) (^{0}C)	Cold water oulet(tco) (^{0}C)	Degree of cooling (thi-tho)	Degree of heating (tci-tco)	Effectiveness of heat exchanger
1.	45	38	27	30	3	7	0.17
2.	45	38	27	29	2	7	0.194
3.	45	39	27	29	2	6	0.197
4.	44	39	27	29	2	5	0.201
5.	44	39	27	29	2	5	0.218
6.	44	40	27	29	2	4	0.211
7.	44	40	27	29	2	4	0.210

Table3:Hot water flowing in tubes and cold water flowing in the shell

VI. CONCLUSION

On the basis of above discussions it is clear that a lot of factors affect the performance of the heat exchanger. Less is the baffle spacing , more is the shell side passes, higher the heat transfer but at the cost of the pressure drop. From the above results we can conclude that the effectiveness of the heat exchanger is more when hot water flows in the tubes and cold water in shell than the cold water in tube and hot water in shell. But the tube material must have good thermal conductivity to transfer temperature from hot water to cold water.

Based on that result we can optimize the design of the shell and tube type heat exchanger. Higher the thermal conductivity of the tube metallurgy higher the heat transfer rate. The simple design of a shell and tube heat exchanger makes it an ideal cooling solution for a wide variety of applications.

REFERENCES

[1] A Gopichand, Prof.A.V.N.L. Sharma, G. Vijay kumar, A. Srividya, “Thermal analysis of shell and tube type heat exchanger using MATLAB and FLOEFD software. ”, Volume 1 Issue :3, ,pp 279-281.
[2] A.O. Adelaja, S.J. Ojolo and M.G. Sobamowo, “Computer Aided Analysis of Thermal and Mechanical Design of Shell and Tube Heat Exchangers”, Advanced Materials Trans Tech Publications Switzerland Vol. 367 (2012), pp731-737,.
[3] B Jayachandriah1, K. Rajsekhar, “Thermal Computer Aided Analysis of Thermal and Mechanical design of shell and tube exchangers,” Advanced materials Trans Tech publications, switzerland vol. 367(2012) pp 731-73,.
[4] Dutta B.K. “Heat Transfer-Principles and Applications”, PHI Pvt. Ltd., New Delhi, 1st ed. 2006.
[5] D. Q. Kern, “Process Heat Transfer”, McGraw-Hill Book Company, Int. ed. 1965.
[6] Ebieto, C.E. and Eke G.B., “Performance Analysis of Shell and Tube Heat Exchangers using Miscible System: A case study”, Journal of Emerging Trends in Engineering and Applied Sciences,2012 3 (5), pp. 899- 903.
[7] Indian Standard (IS: 4503-1967): Specification for Shell and Tube Type Heat Exchangers, BIS 2007, New Delhi.
[8] Rajagapal Thundil Karuppa Raj, Srikanth Ganne, “Shell side numerical analysis of a shell and tube heat exchanger considering the effect of baffle inclination angle on a fluid flow”, Thundil Karuppa Raj, R., et al: Shell side numerical analysis of shell and tube heat exchangers, Thermal science: Year 2012, Vol.16, No.4, pp 1165-1174.
[9] R. K. Sinnott, Coulson & Richardson‟s Chemical Engineering: “Chemical Engineering Design” (volume), Butterworth-Heinemann, 3rd ed. 1999.