2nd International Conference on Latest Advancements & Future Trends in Engineering, Science & Management
Osmania University Centre for International Program, Osmania University Campus, Hyderabad (India)
14th July 2019 www.conferenceworld.in ISBN : 978-81-941721-0-9

Effect of baffle on effectiveness in double pipe heat exchanger

Amar Kumar[1], Amit Kumar Gupta[2] , Ujjwal Kumar Nayak[3]

1&2 Chemical Engineering Department, BIT Sindri Dhanbad
3 Mechanical Engineering Department, BIT Sindri Dhanbad

Abstract

Heat is the amount of energy flowing from one body of matter to another spontaneously due to their temperature difference, or by any means other than through work or the transfer of matter. In this paper, to enhance the heat transfer some baffling is created inside the pipe. In double pipe heat exchanger measuring the effectiveness, overall heat transfer coefficient and heat transfer rate by using without triangular baffles, 50mm and 100mm baffles pitches carried out for both counter and parallel flow in this experiment. Effectiveness of double pipe heat exchanger is found more in counter flow instead of parallel flow. Baffle with small pitch is found more effective.

Key Words: Baffle, Effectiveness, Heat Augmentation, Heat Transfer coefficient and Pitch.

Introduction

Heat exchanger is a device for transferring heat from one medium to another. Heat exchanger is used to transfer heat between a solid object and a fluid. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power station, chemical plants, petroleum refineries, natural -gas processing, and sewage treatment. The classical example of a heat exchanger is project is found in an internal combustion engine in which a circulating fluid know as engine coolant flow through radiator coils and air flows past the coils ,which cools the coolant and heats the incoming air. Study the effect of the baffles on a concentric heat exchanger. Baffles are attached to the heated surface so that it provide an additional heat transfer surface area and to promote useful turbulence .Due to the presence of baffles the flow is separate, reattach and create reverse flow. Recently many experiments have been carried out. Most investigation tells about the optimal baffle geometry that increases heat transfer performance for a flow rate. Dutta (2011) studied the effect of fluctuation of mass flow rate and concept of parallel heat exchangers has been applied. They also studied simulation of helium liquefier system. Eaman Hassan Muhammad (2013) an investigation had been carried out to compare the heat transfer performance of hexagonal pin-fin heat sinks with various commonly used fin geometries. It is found that for the given flow rate and pressure gradient , the Nusselt

ISBN : 978-81-941721-0-9

number of hexagonal fin Wasan Kamsanam et.al (2013) presented in term of heat transfer effectiveness, which is the ratio of actual heat transfer rate to the maximum possible heat transfer rate. The correlations are proposed between the heat transfer effectiveness and the ratios of the fin length to the displacement amplitude and the fin spacing to the thermal penetration depth. The uncertainties associated with all the measurement data are also considered.geometry yield a higher in comparison to square fins, and a lower in comparison to circular fins. Sarmed A Abdal Hussein (2015), has shown heat transfer performance in staggered hexagonal fin geometry is similar in line circular performance at most Reynolds number in the range considered here. The pressure drop does play an important role and becomes another important factor to be considered and to be kept in mind. The maximum value of performance ratio (efficiency enhancement) was found for insert with baffle spacing (15 cm).Nusselt number and friction factor are higher than smooth tube depending on the baffle spacing and mass flow rate of the working fluid. New correlations based on the present experimental datafor predicting Nusselt number and friction factor for the heat exchanger with and without baffle have been proposed. The proposed correlations can predict the experimental data with average relative error of ± 7.8% for Nusselt number and ± 6.5% for friction factor.

Experimental Setup of Triangular Baffled Heat Exchanger (TB-HE)

Figure 1(a) Experimental setup of triangular baffled heat exchanger.

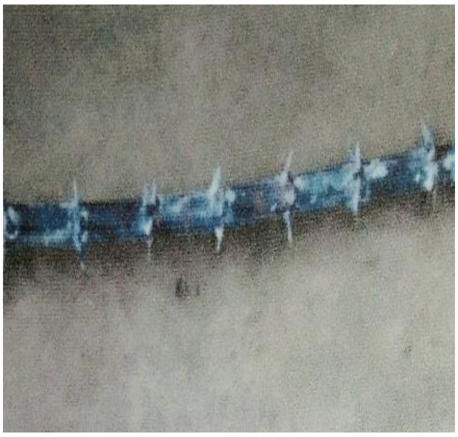

Figure1 (b) Triangular baffles with 50 mm pitch on cu-pipe.

Working principle

Experimental set-up of double concentric tube heat exchanger is shown in figure 1(a) and (b). In this two flowing fluids at different temperature is separated by a solid copper wall. In the experiment heat is first transferred from inner hot fluid to Cu-wall by convection after that by conduction through the

ISBN : 978-81-941721-0-9

thickness of cu- tube and finally outer surface of Cu-tube to the cold fluid flowing in annulus is by convection.

Hot water was circulated with the help of pump at a constant mass flow rate and different temperature s of water are achieved by geyser and mass flow rate of hot water is determined by calculating time to fill a bucket of known volume. Cold water is circulated by gravity force and valve openings and mass flow rate is calculated with the help of manometer reading which is connected to an orifice meter. Temperature at inlet and outlet of both the fluid is determined by thermocouple attached with digital temperature (DTI). Parallel and counter flow arrangement s is made with the help of set of valves opening and closing.

In the first experiment, the effect of mass flow rate of water on thermal performance of simple heat exchanger is calculated for both parallel and counter flow arrangements. And same procedure is repeated for triangular baffled heat exchanger for two different pitches of baffles.

Data Reduction

Mathematical expression of heat exchanger

Following symbol have been used for calculation

U is the overall heat overall heat transfer coefficient due to various modes of heat transfer

"A" is the total surface area of heat transfer, t_1 and t_2 is the inlet and outlet fluid temperatures,

Now the overall energy balance in a heat exchanger.

m= mass flow rate (Kg/sec)

Cp, specific heat of fluid at constant pressure (J/Kg℃)

t= temperature of fluid (℃)

Δt=temperature drop or rise of a fluid across the heat exchanger (℃)

H_1 and H_2 refer to cold fluid corresponding to inlet and outlet

C_1 and C_2 refer to cold fluid corresponding to inlet and outlet

Assuming that there is no heat loss to the surroundings and potential and kinetic energy

Changes are negligible from the energy balance in a heat exchanger.

We have

ISBN : 978-81-941721-0-9

Heat give up by the hot fluid

$Q= m_h\, Cph\, (t_{h1}-t_{h2})$ ……………..(1)

Heat picked up by the cold fluid

Total heat transfer rate in the heat exchanger

Q=U.A.Δ□$_m$……………..(2)

Where,

U=Overall heat transfer coefficient between Δtwo fluids,

A=Effective heat transfer area,

Δ□m= logarithmic mean temperature difference (LMTD)

Where, Δ□$_m$ $=\frac{(\theta_1-\theta_2)}{ln(\theta_1/\theta_2)}$…………… (3)

The heat exchanger effectiveness (□) is defined as the ratio of actual heat transfer to the maximum possible heat transfer, thus

□ $=\frac{actual\ heat\ transfer}{maximum\ possible\ heat\ transfer}=\frac{Qactual}{Qmaximum}$....................... (4)

Result and Discussion

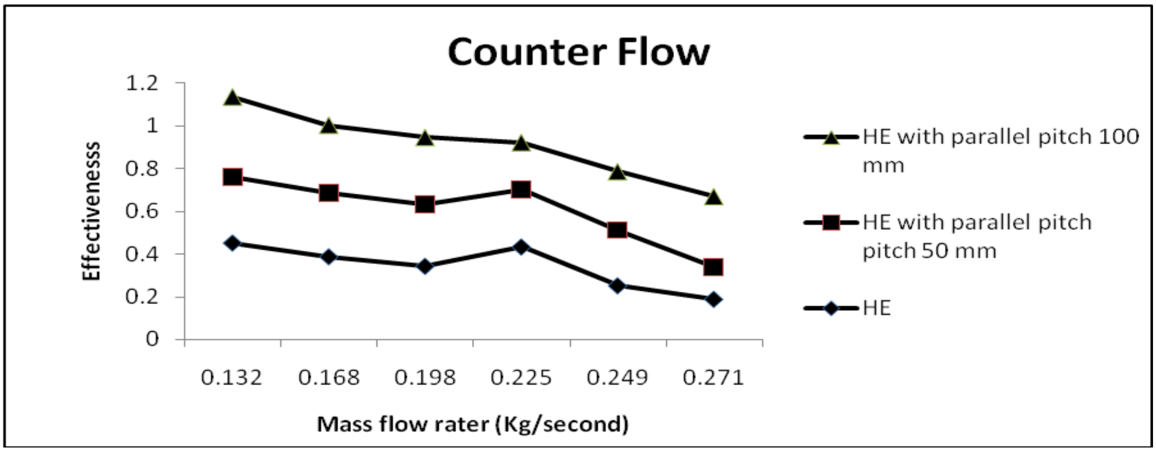

Figure 2 Variation of effectiveness with mass flow rate of counter flow.

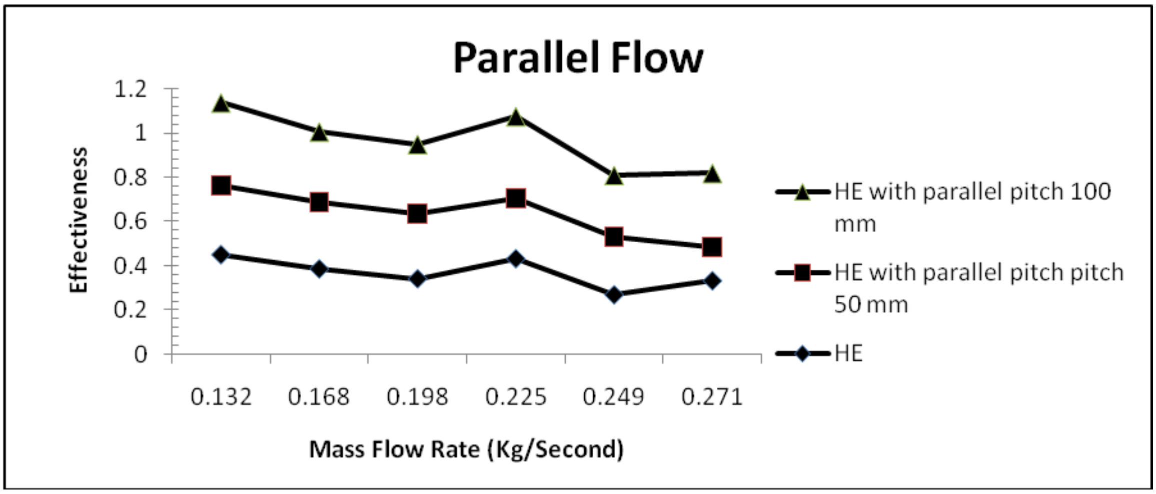

Figure 3 Variation of effectiveness with mass flow rate of parallel flow.

Figure 2 and 3 show the variations of effectiveness with different mass flows rate of cold fluid for parallel and counter flow respectively. The plot clearly shows that the effectiveness decreases with increasing mass flow rate. Effectiveness of both triangular baffled heat exchangers is greater than the plane tube heat exchanger. However from two graphs it is also clearly seen that the effectiveness of heat exchanger with 50 mm triangular baffled pitch is more than 100 mm pitch. So it can be concluded that using of baffles in heat exchanger effectiveness increases however if baffles pitch decreases effectiveness also increase.

Conclusion

In double pipe heat exchanger measuring the effectiveness, without triangular baffles, 50mm and 100mm baffles pitches carried out for both counter and parallel flow in this experiment. These are following conclusions.

- Using 50mm and 100mm pitches of triangular baffle are measuring effectiveness 1.23 and 1.27 times in counter flow and 1.39 and 1.47 in parallel flow.
- Using 50mm and 100mm pitches of triangular baffle are measuring average heat transfer rate 1.25 and 1.36 times in parallel flow and 1.21 and 1.48 in counter flow in soap water solution. Increases the average heat transfer rate in both counter and parallel flow.
- The average effectiveness 1.32 and 1.42 times in parallel flow and 1.38 and 1.51 in counter flow by using triangular baffle of 50mm and 100mm pitches.
- The baffle spacing decreases then the effectiveness, heat transfer coefficient and heat tare are increases in counter and parallel flow.

- The average heat transfer rate increase 1.3 and 1.5 times in parallel flow and 1.32 and 1.51 in counter flows that of triangular baffles of 50mm and 100mm pitches.
- In the observations heat loss by hot fluid is more than heat gain by cold fluid because of insulation. Heat exchanger performance affected by the insulation.
- From the results it can be concluded that the performance of triangular baffled heat exchanger is much better water to soap water. Therefore improvement in the energy saving use in different application.

References

Dutta, R., Ghosh. P. And Chowdhury, K., 2011, "Application of parallel Heat Exchangers in Helium Refrigerators for Mitigating effects of Pulsed Load from Fusion Devices," Fusion Eng. And Devices . 86.pp. 296-306.

Eaman Hassan Muhammad (2013)," A Comparison of the Heat Transfer Performance of a Hexagonal Pin Fin with Other Types of Pin Fin Heat Sinks" , International Journal of Science and Research (IJSR), 1781 – 1788.

Holman JP.Experimental methods for engineers. 7thed (Chapter 3). New Delhi: Tata McGraw-Hill , 2007.

Kothandaraman C . P. andSubramanyan S,(2007) Heat and mass transfer data book, New age publication. Sixth edition.

WasanKamasanam, Xiaoan Mao and Artur J. Jaworski (2013)"Experimental Investigagation of Heat Transfer Effectiveness on Finned-Tube Thermocouple Heat Exchanger.'

Sarmed A Abdal Hussein (2015), "Experimental investigation of Double Pipe Heat Exchanger by using Semi Circular Disc Baffles", International Journal of Computer Applications, Volume 115 – No, 4, 13 – 17.10.