Study experimental of the effect of baffle spacing to the effectiveness shell and tube heat exchanger

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Abstract. Utilization of heat exchanger shell and tube to now days increasingly vast mainly in the field of industry and technology. The purpose of the study was to know the effect of arrangement distance the baffe of the effectiveness of the heat exchanger type shell and tube used a type single pass baffles. The object of this experimental study is a heat exchanger type shell and tube with variations within the baffle , which laying baffle do with varations the distance between the other 40mm, 50mm, 55mm and 60 mm and types baffle the use the single pass baffles. Resultts showed the highest effectiveness to distance of baffle 40 mm that is equal to 44.8 %. Thus we can conclude the closer the baffle will increase the effectiveness of the heat exchanger.

1. Introduction

Heat exchangers are one of the most used devices in the indutries to regulate efficiently transfer heat in industrial process applications. It is widely used in many engineering applications such as chemical engineering process and power generation [1], refrigeration and water heater [2, 3]. Among different types of heat exchangers, shell and tube heat exchangers are relatively easy to manufacture and have multipurpose application possibilities for gaseous as well as liquid media in large temperature and pressure [4, 5]. In shell and tube heat exchanger, two fluids of different temperature flow through the heat exchange. One flows through the tubes (the tube side) and other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls. The fluids can either be liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area is used, leading to the use of many tubes. This is an efficient way to use energy and avoid wastage of thermal energy.

A variety of different strategies are available to improve the performance of shell-and-tube type heat exchanger. In its structure, baffles are one of the most important parts. The function of baffles is that they force the fluid of shell side to flow across the tubes to ensure high heat transfer rates and provide support for tube bundle [6]. In the past, optimization of baffle of shell-and-tube heat exchangers will be used to improve performance. Optimization of baffle spacing and proposed appropriate correlations [7-9], effect of baffle configuration on heat transfer rate and pressure drop [10, 11], effect of baffle clearance on the flow direction in the shell side [12], effect of baffle inclination on the flow characteristics [13-16], etc. Heat exchanger type shell and tube, there are some things that need to be considered to obtain the effectiveness of heat transfer up to, among other types of fluid flow rate, temperature, the distance baffle, In a shell and tube heat exchanger, one fluid flows through the sleeve and the other fluid flows through the small pipes

As presented in the above literature, many researchers studied the influence of baffle configurations on shell and tube heat exchanger performance. However, the effect of different new baffle configurations such as variation of baffle, inclanation angle of baffle, and material on shell and tube heat exchanger, baffle spacing have not been studied yet. The objective of this study is to explore the effect of the baffle scaping on the effectiveness of a shell and tube heat exchanger. Investigation is present a comparative study of a shell and tube heat exchnager with various baffles spacing based on experimental analyses.

2. Solution Method

Schematic diagram of the experimental set-up is shown in "figure 2.1" and the heat exchanger shell and tube in "figure 2.2" respectively. The experimental apparatus is formed by two concentric tubes in which water (cold in the inlet, hot in the outlet tube) flows through them with different direction. The inner tube is a Copper tube with dimension of (d_i = 13 mm, d_o=16 mm) while the outer tube is with iron pipe (d_0 = 165 mm, d_i=157 mm), dimensions. The length of the heat exchanger,pressure tape are 665 mm. The present paper mainly attempts to study the different effects in shell-and-tube heat exchanger by baffle spacing at 40 mm, 50 mm, and 60 mm. The working fluid used is deionized water.

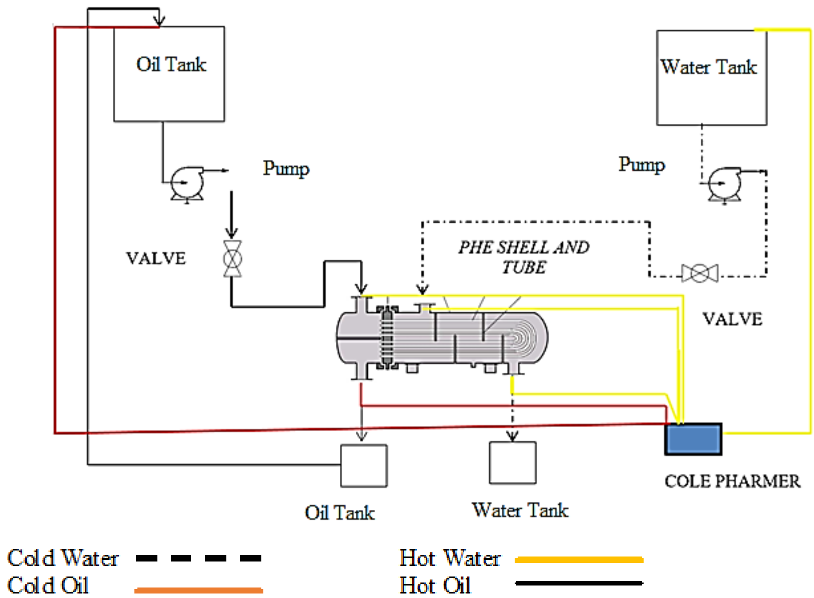

Figure 2.1 Set-up experimental shell and tube heat exchanger

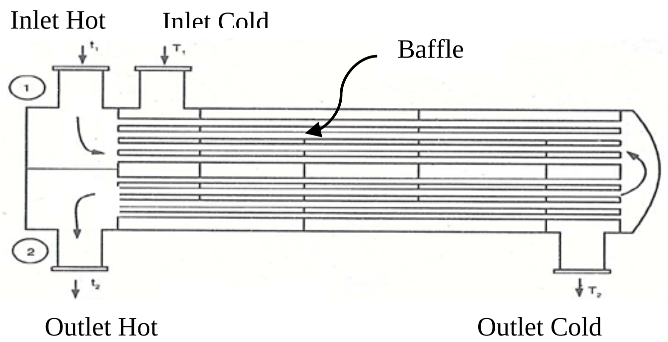

Figure 2.2 Shell and tube heat exchanger

Principal calculation of heat exchanger is the problem of heat transfer. If the heat released is the same as Q the time unity, then the heat received by the cold fluid of Q is calculated by Log Mean Temperature Difference (LMTD) equation (1)

$$Q=U.A.\Delta T.m \quad (1)$$

Heat transfer process is determined by the type of fluid stream that flows inside a heat exchanger. In this journal the fluid flow that occurs is parallel-counter flow. Thermal coefficient on the shell is calculated by equation (2)

$$\frac{h_0}{\varphi s} = JH \ \frac{k}{De} \ .Pr^{1/3} \quad (2)$$

Prandtl Number is given by the equation (3)

$$Pr = \frac{Cp.\mu}{k} \quad (3)$$

Reynold number on shell fluid is given by equation (4)

$$Re_s \ = \frac{Gs.De}{\mu} \quad (4)$$

Fluid mass velocity is calculated by the equation (5)

$$G_s \ = \frac{m}{As} \quad (5)$$

The flow area of the shell is determined by the equation (6)

$$A_s \ = \frac{Ds.C.B}{Pt} \quad (6)$$

The equivalent diameter De can be determined if the pipe arrangement is known and calculated by the equation (7)

$$D_e \ = \frac{(P_t{}^2 - \pi \frac{do^2}{4})}{\pi.d_o} \quad (7)$$

The amount of coefficient of heat transfer that occurs on the tube side is caluclated by the following equation (8)

$$\frac{h_i}{\varphi t} = JH \ \frac{k}{din} \ .Pr^{1/3} \quad (8)$$

Also determined the amount of tube Reynolds number in the following equation (9)

$$Re_t \ = \frac{di.Gt}{\mu} \quad (9)$$

The Impurities Factor is calculated by the following equation (10)

$$R_d \ = \frac{Uc-Ud}{Uc.Ud} \quad (10)$$

The overall heat transfer coefficient can be calculated by the following equation (11)

$$U_D = (1/Uc + R_D)^{-1} \quad (11)$$

Because C_h = Cmin, the effectiveness of the heat exchanger can be calculated by the following equation (12)

$$\varepsilon = \frac{T_{hi}-T_{ho}}{T_{hi}-T_{ci}} \quad (12)$$

3. Results and Discussion

In this study focus to explore the effect of the baffle spacing to the performance of the heat exchanger. The heat transfer rate and effectiveness are estimated by using temperature data resulted from data experimental. The results of the calculation as a whole will be displayed in table 1. In the figure 1 and figure 2 show temperature changes in the tube and in the shell side can be seen. In the cold side, fluid in the shell, increase from the inlet to the outlet. On the other hand, in the hot fluid within the tube, temperature decreased as the flow close to the exit. The temperature of the incoming hot fluid (Th,i) 70^0C and the temperature of the incoming cold fluid (Tc,i) 27^0C at the inlet of the hot fluid 1.8 litre/minute and discharge of cold fluid 10 litre / minute. The fluid that is analyzed as a hot fluid and a cold fluid is water.

Table 1.Data Experimental of the shell and tube heat exchanger

Baffle Spacing (mm)	Total Baffle	T hot (In)	T hot (out)	T cold (in)	T cold (out)
40	12	70.43	51.08	27.28	34.86
50	10	70.43	55.24	27.65	35.49
60	8	70.61	58.68	27.01	35.66

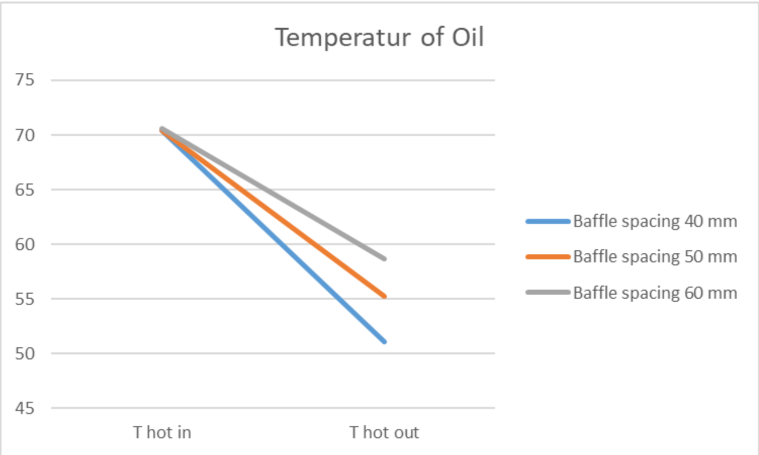

Figure 3.1 Graph of temperature inlet and outlet of oil

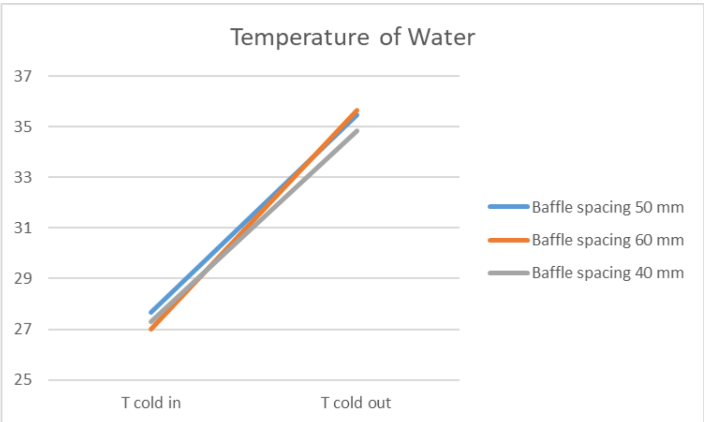

Figure 3.2 Graph of Temperature inlet and outlet of water

The temperature of oil and temperature of water was shown in figure 3.1 and figure 3.2, decrease temperature of oil in baffle spacing 40 mm higher than 50 mm and 60 mm at the temperature of the inlet hot fluid (Th,i) 70.61 °C and the temperature oulet (Th,o) 51 ^{0}C. The maximum temperature of water outlet is 34.86 ^{0}C. It is because at low baffle spacing is better than at high baffle spacing.This fact suggest that decreasing baffle spacing will increase the temperature change in both fluid flow.

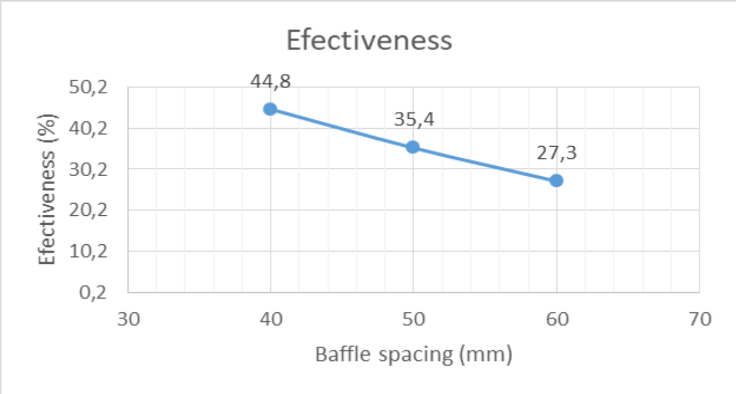

Figure 3.3 Graph of baffle spacing with effectiveness

From the calculation of the data in the field, the minimum heat exchanger effectiveness is 27.3 % at the temperature of the incoming hot fluid (Th, i) 70.61 ° C and the temperature of the incoming cold fluid (Tc, i) 27.01 °C at the inlet of hot fluid 1.8 l/minute and discharge of cold fluida 10 l/minute.While the maximum heat exchanger effectiveness is 44.8 % at the temperature of the incoming hot fluid (Th, i) 70.43 °C and the temperature of the incoming cold fluid (Tc, i) 27.28 °C at the inlet of the hot fluid 1.8 l/minute and the cold fluid inlet 10 l/minute.

The effectiveness shell and tube heat exchanger can be maximum that increase the number of baffles decreases the spacing between the baffles and hence the flow stream undergoes sharp change in direction as it passes the baffle. This causes more dead flow zone at the corner between the baffles and the shell wall. In order to make a clear examination on the effect of the baffle spacing to the effectiveness of the heat exchanger, the calculations have been made. The temperature effectiveness of the heat exchanger at different baffle spacing are shown in table 2. The effectiveness is calculated using all the temperature in the inlet and outlet of each fluid. The temperature inlets are given, while the temperature outlets are drawn from the numerical simulation. In the simulation, heat transfer rate between hot fluid flow and cold fluid flow is calculated. The results at different baffle spacing are also shown in table 2 and table 2 shows that increasing baffle spacing will decrease heat transfer rate in the heat exchanger. This is due to lower heat transfer rate at higher baffle spacing. As expected, increasing baffle spacing will decreasing temperature effectiveness of the heat exchanger.

Table 2.Effectiveness of heat exchanger

Baffle Spacing (mm)	Effectiveness (%)
40	44.8
50	35.4
60	27.3

4. Conclusions

Decrease speacing of baffles gives high effect on temperature of fluid. The effectiveness shell and tube heat exchanger can be maximum that increase the number of baffles and decreases the spacing of baffles. The maximum of effectiveness is 44.8 % with 40 mm space of baffle from variation of baffle spacing 40 mm, 50 mm and 60 mm.

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