Journal of Mechanical Engineering Research and Developments
ISSN: 1024-1752
CODEN: JERDFO
Vol. 43, No. 3, pp. 332-338
Published Year 2020

Experimental Study of Baffle Angle Effect On Heat Transfer Effectiveness Of The Shell And Tube Heat Exchanger Using Helical Baffle

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ABSTRACT: Baffles are one of the important components in heat exchangers that conduct insulation and to facilitate fluid contact in order to increase heat transfer. From previous studies, optimal baffle angle is not found yet, further research is needed of variations in appearance 5^0, 6^0, and 7^0 helical baffle. The purpose of this study was to determine the variation of helical baffle research on the evaluation of shell and tube heat exchanger. This study used shell and tube heat exchanger and helical baffles with helical variations of 5^0, 6^0, and 7^0 then the data obtained was calculated and described using tables and graphs. At 5^0 baffle got effetiveness 50.8%, at 6^0 baffle got results effectiveness 42.8 % and at the baffle 7^0 angle got results 31.4%. Thus, the most optimal results are in the variation of 5^0 because fluid would take longer to flow so that heat transfer would get better.

KEYWORDS: shell and tube heat exchanger, effectiveness, helical baffle, angle of baffle.

INTRODUCTION

Heat Exchanger is a device used to transfer heat effectively between two liquids [1,2]. The function of the heat exchanger is not only limited to the cooling process but is also functioned for the heating process. From the existing system, it is no longer a secret that heat exchangers are an important part of an industry. Many types of heat exchangers are made and used in power stations, cooling units, air conditioning units, industrial processes, gas turbines, etc. [3].

Shell and tube heat exchangers in various forms are probably the most extensive and most commonly used equipment in industrial processes. The heat exchanger shell and tube consists of a shell (outer shell) and inside there is a tube (small tubes). Fluid that has a temperature difference, flows in the shell and in the tube where the two fluids do not mix with each other. The flow direction of the two fluids can occur in parallel, counter, cross or mixture [4].

Shell and tube heat exchangers have characteristics, namely strong construction, flexibility and easy maintenance. Shell and tube heat exchangers are designed based on certain standards such as geometry, process size, and overall system. To design a shell and tube heat exchanger, it is expected to produce high transfer efficiency. To produce high heat transfer it is necessary to consider good material for the shell and tube heat exchanger.

A good material for designing a shell and tube heat exchanger is a material that can conduct heat well, meaning that it must have high thermal conductivity [5]. To produce high heat transfer it is necessary to consider good material for the shell and tube heat exchanger. For the selection of shell and tube heat exchanger materials, in addition to being noted the thermal conductivity of the material must be considered the properties of the material such as corrosion resistance and others.

Poor selection of shell and tube heat exchanger material can cause leaks in the shell and tube heat exchanger. If there is a leak, the fluid flowing in the shell or tube can be mixed and contaminated. And Standard construction and use of shell and tube heat exchangers generally use the TEMA standard (Tubular Exchanger Manufactures Association). One of the important components in the heat exchanger is the baffle. The baffle is a seal in the shell

and tube that serves to expand fluid contact so that heat transfer in both fluids increases. The baffle also functions as a buffer tube so as not to bend due to the vibration of the fluid flow [6].
There are several types of baffles that can be used in shell and tube heat exchangers, namely single segmental, double segmental, triple segmental, no tube in window, helical, disc and donut, and grid. In this research using a helical baffle type, Helical baffles are helical-shaped baffles. Helical baffles produce swirling flow to avoid bypass flow and stagnant flow areas that are common in segmental baffles. This type of baffle is effective for low to high viscosity fluids. Generally used in oil refineries and refrigeration. The current research focuses on the helical variation in the baffle design so the author takes the topic" experimental study of the effect of baffle angle variation on heat transfer effectiveness in shell and tube heat exchanger using helical baffle type ".

Shinde [7] reviewed about the performance of single phase tubular shows that helical baffles can develop more performance from heat exchangers compared to segmental baffles. The advantage of helical baffles is the tendency for low tube vibrations because the tubes are supported by helical baffles and lower shell side fouling. Wang et al. [8] shows that helical baffles are baffle types that have a relatively high heat transfer efficiency, which is about 20-30% higher than segmental baffles. Kurniawan [9] conducted an experimental study comparing the effectiveness of shell and tube heat exchangers using helical baffles with shell and tube heat exchangers using double segmental baffles. In that research, Kurniawan used a helical baffle angle of 19^0. The results obtained showed the effectiveness value of the shell and tube heat exchanger variation of the double segmental baffle type by 29.51%, and using a variation of the helical baffle type the effectiveness value of the shell and tube heat exchanger was by 34.89%.Husainy et al. [10**]** studied a research with helical baffles with variations in baffle angles of 7^0 and 13^0 , the coefficient of convection heat transfer will increase with decreasing baffle angles at the same flowrate. So, in this study focusses on experimental study of baffle angle on effectiveness of helical baffle. The experiment uses three angle variations of baffles namely 6^0, 7^0, 8^0.

METHODS

The author uses the type of experimental research, which aims to determine the effectiveness affected by variation in the angle of the helical baffle on shell and tube heat exchanger. The analysis in this study was carried out by taking data from instruments contained in the research object.

Table 1. Specifications of shell and tube heat exchanger

No.	Component	Classification of Construction	Dimension
1	Fluid	Flow	Counter flow
		Type of heat transfer	Indirect contact
		Fluid passageways	One phase
		The fluid in the shell side	Water
		The fluid in the tube	Water
		The temperature of cold fluid inlet on the side of the shell	30°C
		The temperature of the hot fluid inlet on the side of the tube	80°C
2	Shell	The outer diameter of the shell	170 mm
		The diameter of the shell	164 mm
		The length of the shell	960 mm
		Material shell	Stainless steel
		The number of passes on the shell side	1 passes
3	Tube	Total tube	12
		The outer diameter of tube	12.7 mm
		The thickness of the tube	0.8 mm
		The length of tube	966 mm
		Material tube	Copper
		Number of passes tube	1 passes
		The composition of the tube	Rotate triangular 60^0
		Tube pitch	45 mm

Shell and tube heat exchanger is a trainer used to test as shown the figure 1.

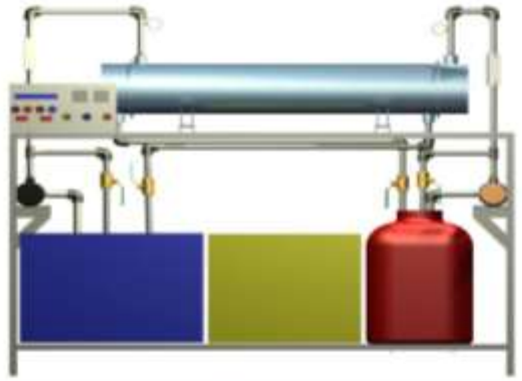

Figure 1. Shell and Tube Heat Exchanger Trainer

Baffle

The baffle used in this research are helical baffle. The advantage of using helical baffles is that it has a relatively high heat transfer efficiency compared to the others.
Specification of baffle:

Table 2. Specifications of baffle

1	Baffle	Diameter baffle	164 mm
		Material baffle	Aluminum
		The thickness of the baffle	3 mm
		Helix angle	6^0, 7^0, and 8^0

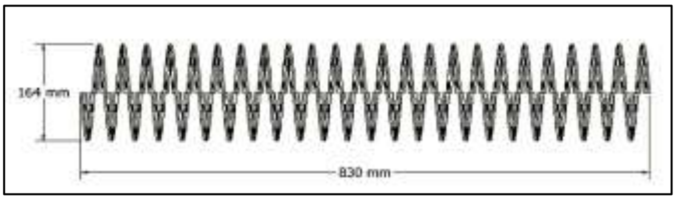

Figure 2. Design of Helical Baffle

(a) (b) (c)

Figure 3. Helical Baffle in difference angle: (a) 5^0 (b) 6^0 (c) 7^0

Data retrieval can be done as follows:

The first step is preparing shell and tube heat exchanger according to the data properties. Second step, the cold fluid at 30^0 in shell side is circulated for 4 minutes and hot fluid at 80^0 in tube side is circulated for 2 minutes.

After the two fluids enter each side of the shell and tube side, the heat transfer process undergoes. Then the pressure, Th_{out} and Tc_{out} data are taken and do the same procedure for other variables.

Heat Transfer Analysis

Heat transfer rate on the side of the tube [11] :

$$Q_h = \dot{m}_h \cdot C_{p,h} \cdot (T_{h,i} - T_{h,o}) \quad (1)$$

Heat transfer rate on the shell side :

$$Q_c = \dot{m}_c \cdot C_{p,c} \cdot (T_{c,i} - T_{c,o}) \quad (2)$$

Rate of Heat Capacity in Shell Side Fluid (Cc)

$$C_c = \dot{m}_c \times Cp_c \quad (3)$$

Rate of Heat Capacity in tube Side Fluid (Ch)

$$C_h = \dot{m}_h \times Cp_h \quad (4)$$

Maximum heat transfer rate :

$$Q_{max} = C_{min} \times (T_{h,in} - T_{c,in}) \quad (5)$$

where:

$C_c > C_h$. Then, $C_{max} = C_c$

$$C_{min} = C_h. \quad (6)$$

Hence, effectiveness can be evaluated by:

$$\varepsilon = \frac{Q_{aktual}}{Q_{max}} \times 100\% \quad (7)$$

RESULTS AND DISCUSSION

Based on the results of tests and calculations that have been done, the data obtained in the form of figures that are not fully understood. The data that has been obtained and written in the form of the table will be described in graphical form and will be described data that has been obtained in the form of sentences that are easy to read and easy to understand.

Effect of baffle angle variations on the Difference in Inlet and Outflow Fluid Temperature (ΔT)

The variation of the baffle angle with (ΔTh) and (ΔTc) that the smaller the angle will enlarge (ΔTh) while the value (ΔTc) will decrease if the angle gets smaller. This is because the more baffles, the lower the temperature of heat passing through the tube due to obstruction by the number of baffles and the narrower the angle of the baffles. The smaller angle, it will absorb heat faster so that the heat transfer from hot fluid which has a higher temperature, to cold fluid that has a lower temperature, becomes larger [12].

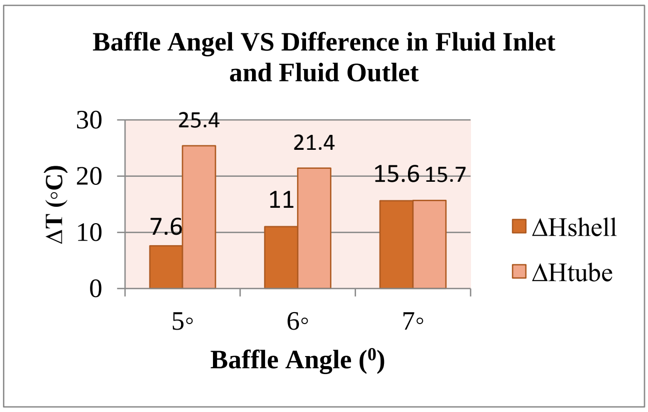

Figure 4. The Effect of Baffle Angles on the Difference in Incoming and Outgoing Fluid Temperature (ΔT)

Overall Heat Transfer Coefficient (U)

From the graph it could be seen that the overall heat transfer rate (U) will increase with the magnitude of the baffle angle. This is because the rate of heat transfer is influenced by the value of the convection and conduction heat transfer coefficient on the shell or tube [13]. The coefficient of heat convection that occurs in the shell is smaller than the tube, which makes the value of heat transfer absorbed by large cold fluid, resulting in U is also large.

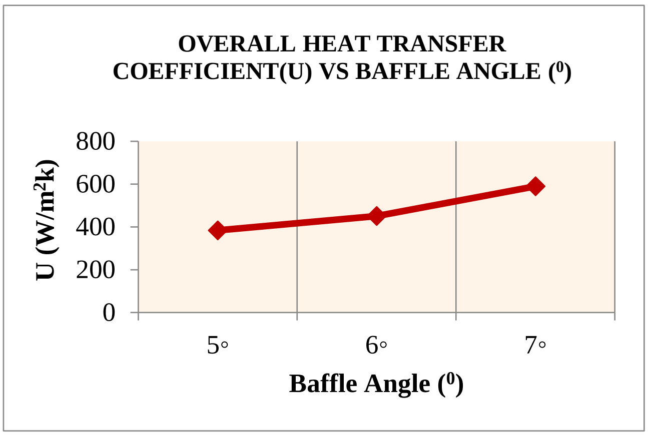

Figure 5. Overall heat transfer coefficient as function of baffle angle

Effect of Baffle Angle Variations on Heat Transfer Rate (q)

Rate of heat transfer will increase as the angle increases. This is because the overall heat transfer rate (U) rises causing the heat transfer rate (q) to rise.

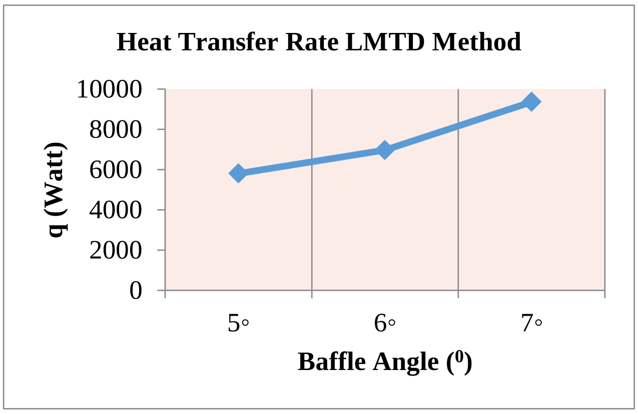

Figure 6. Effect of Baffle Angle Variations on Heat Transfer Rate (q)

Maximum Heat Transfer Rate (qmax)

Shows a decrease in the maximum heat value if the angle is greater. Based on this, it can be concluded that the maximum heat transfer rate will increase if the angle gets smaller, because the fluid contact will flow longer so that the heat transfer will be better and the maximum transfer value (qmax) affects the value of effectiveness on the shell and tube Heat Exchanger [14]. The graph plotted between helical angle and maximum heat transfer rate is shown in the below pig 7. The highest maximum heat transfer rate is show at angle variation in 5^0 baffle angle.

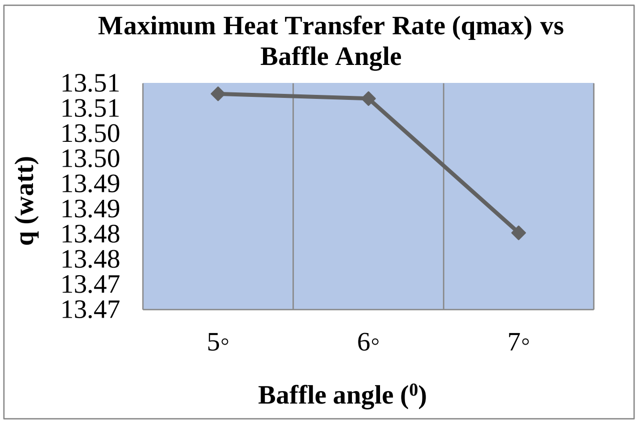

Figure 7. Maximum Heat transfer as function of baffle angle

Effectiveness Shell and Tube Heat Exchanger

Illustrates the increase in effectiveness as the baffle angle gets smaller.the highest effectiveness value obtained is reaching 50.8% when the helical variation is 5^0. This is because the smaller the angle acting on the heat exchanger, the geometry of the helical baffle makes the total of heat transfer greater [15]. This happens because the smaller and more number of baffle will cause the fluid to flow for longer so that the heat transfer will be better and increase the effectiveness of the shell and tube heat exchanger [16].

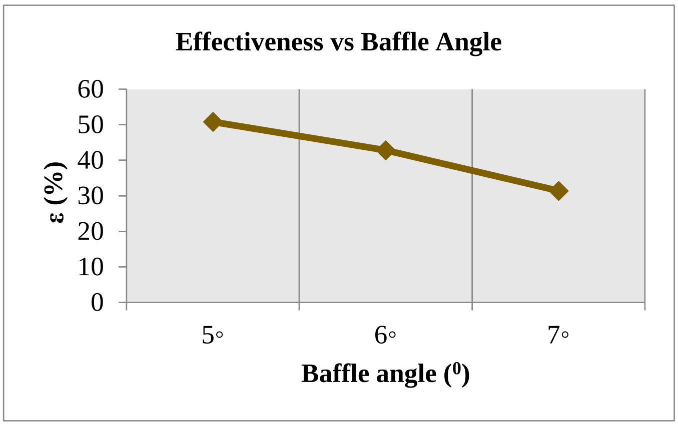

Figure 8. Effectiveness as function of baffle angle

CONCLUSION

Based on the results of the experimental study of the effect of baffle temperature on the effectiveness of heat transfer from the heat exchanger and tube heat exchanger using helical baffle. It was found that at 5^0 baffles get 50.8% effectiveness, at 6^0 baffles get 42.8% effectiveness results and at baffle angle 7^0 get 31.4% benefit results. Thus, the most optimal results are in a variation of 5^0 with a result of 50.8%. because the smaller the angle, the fluid will need more time to flow so that the heat transfer will be better. Concerning to the results of this study on shell and tube heat exchangers using helical baffles are expected to provide an overview and input for industries that use this type of heat exchanger and can be used as input for further research.

ACKNOWLEDGEMENT

The author would like to express their most sincere thanks to Heat transfer laboratorium of Universitas Negeri Surabaya (UNESA) for their technical support during this study.

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