



Analysis Of Three Layer Concentric Tube Heat Exchange Using Mathematic Modeling

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ABSTRACT

A three-channel concentric pipes heat exchanger is a development or improvement of a two-channel concentric heat exchange apparatus. This study was conducted to determine the output temperature of each channel, and compare the results of theoretical calculations using mathematical modeling of experimental results conducted in the field. So that obtained difference of value between result of experiment to result of theory calculation. In this study have 3 variations of temperature data that is 50 °C, 55°C, and 60 °C with two streams namely CounterFlow and PararellFlow and discharge 2.5 l/minute, while cold fluid with 25 °C discharge 1.5 l/minute. From the above analysis it can be concluded that the temperature of the hot fluid coming out of the APK in the experiment tends to be higher than the temperature of the hot fluid coming out of the APK on theoretical calculations of mathematical modeling methods. Meanwhile, the cold cold fluid temperature coming out of the APK in experimental tends to be lower than the temperature of the cold fluid coming out of the APK on theoretical calculations of mathematical modeling methods.

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1. INTRODUCTION

Along with the times, the era of globalization cannot be avoided, which is marked by the emergence of various kinds of technology that are useful for making it easier for humans to carry out various activities. This technology was created not only to facilitate human work, but also to increase economic value which has an impact on the level of human welfare itself. It is undeniable that the development of the times also has an impact on human needs.

In the industrial world, a tool called a heat exchanger is very widely used. Various types of heat exchangers are used to achieve the desired purpose, such as to heat the product or to cool the product. To develop technology, especially heat exchangers, therefore in this case it is necessary to engineer the technology of heat exchangers, in this case also carried out the development of a heat exchanger with a three-layer type of concentric tube (triple concentric tube heat exchanger), this type has advantages in In terms of effectiveness and efficiency of performance of this type of heat exchanger, double tube heat exchanger, therefore this type of heat exchanger needs to be developed and researched further. In its development the heat exchanger undergoes a shape

transformation which aims to increase efficiency in accordance with its work function. Heat exchanger is an important medium in the industrial world. For this reason, in this final project, a triple concentric tube heat exchanger model that functions as a water heater and cooler is planned but still refers to the existing design rules. So that it can be used as a learning method regarding the design process, working mechanism, and heat exchanger performance

2. RESEARCH METHOD

The data processing is carried out in several parts, where the data obtained from the test will be calculated for its effectiveness value using a formula.

After the test is complete, the data to be processed will be obtained, where the data recorded by the Thermocouple is still raw data to be processed so as to obtain the effectiveness value of each test.

3. RESULTS AND DISCUSSIONS

3.1 Counter Flow flow analysis

In calculating the data, this research was carried out using mathematical modeling methods to find the value of the three APK pipes. By using the equation in chapter 2, the data needed are , debit, radius of each pipe, , and h. The data was obtained from the experiments carried out.

Table 1.Calculation Data

Pipe	(K)	Debit (m ³ /s)	Finger (r)		h	
1	298	0.0249 /s X	1.27X m	4.180kJ/kg.K	509,7237W/ .K	?
2	333	0.0415 /s X	2.54X m	4.185kJ/kg.K	1123.08 W/ .K	?
3	298	0.0249 /s X	4.45X m	4.180kJ/kg.K	773.46 W/ .K	?

3.2 Graph Analysis Theory and Experiment Counter Flow

After calculating for the three variations of the hot fluid inlet, the results of these calculations can be presented in the following table:

Table 2. theoretical calculation results and the results of the 1 Counter Flow Pipe Experiment

(°C)	Theory(°C)	Experiment(°C)
60	52.15	48.85
55	50,60	47.47
50	48,58	45,13

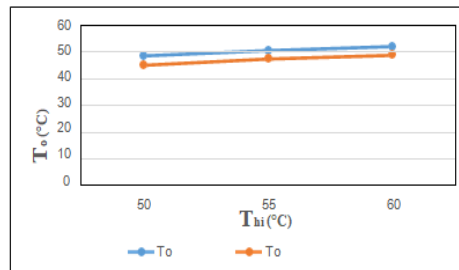


Figure 1. Comparison of Theory and Experiment on pipe 1 Counter flow

In the table and graph above, the comparison data between theory and experiment on pipe 1 for 60, 55, and 50 °C is obtained, namely 93.7%, 93.8%, and 92.8%.

Table 3.The results of theoretical calculations and the results of the 2 Counter flow Pipe Experiment

(°C)	Theory(°C)	Experiment(°C)
60	30.45	34.57

55	28.05	32.42
50	25.99	29.05

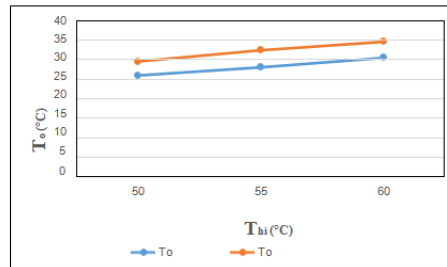


Figure 2. Comparison of Theory and Experiments on 2 Counter flow pipes

In the table and graph above, the comparison data between theory and experiment on pipe 2 for 60, 55, and 50 °C is obtained, namely 86.5%, 84.4%, and 88.2%.

Table 4. theoretical calculation results and the results of the 3 Counter flow Pipe Experiment

(°C)	Theory(°C)	Experiment(°C)
60	55.14	44.38
55	52.26	44.57
50	49.10	43.11

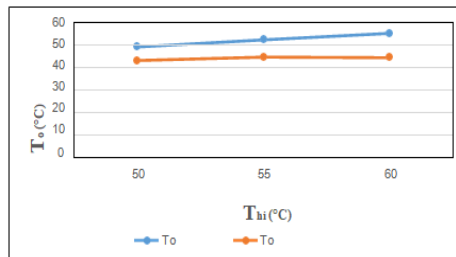


Figure 3. Comparison of Theory and Experiments on 3 Counter flow pipes

In the table and graph above, the comparison data between theory and experiment on pipe 3 for 60, 55, and 50 °C is obtained, namely 80.4%, 85.3%, and 87.8%.

$$= - [456.68 \times (1 - 0.599280) + (1193.103 \times 0.599280)]$$

$$= - 0.896720$$

$$= - [(456.68 \times 0.599280) + (1193.103 \times 0.599280)]$$

$$= - 0.986090$$

$$= - [(456.68 \times 0.599280) + (1193.103 \times (1 - 0.599280))]$$

$$= - 0.752279$$

By substituting the value of F above in equations 2.33 to 2.53, we get the values of T_{o1} , T_{o2} , and T_{o3} and namely:

$$= 55.82^\circ\text{C}$$

$$= 36.08^\circ\text{C}$$

$$= 56.56^\circ\text{C}$$

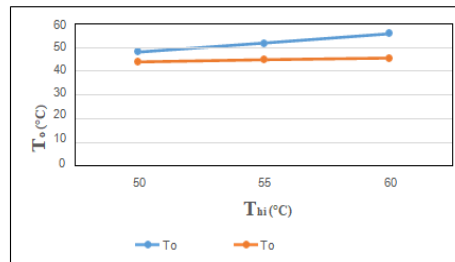
After obtaining the values of T_{o1} , T_{o2} , and T_{o3} , then repeat the above method for temperatures of 50°C and 55°C.

a. Parallel Flow Theory and Experimental Graph Analysis

After calculating for the three variations of the hot fluid inlet, the results of these calculations can be presented in the following table:

Table 5. Theoretical calculation results and the results of the ParallelFlow 1 Pipe Experiment

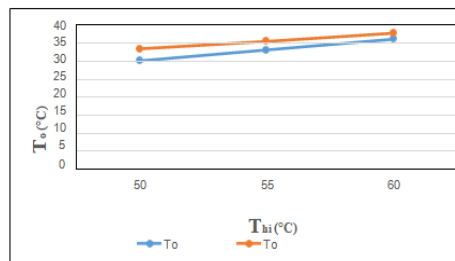
(°C)	Theory(°C)	Experiment(°C)
60	55.82	45.54
55	51.94	44.89
50	48.07	43.98

**Figure 4.** Comparison of Theory and Experiments on ParallelFlow 1 pipe

In the table and graph above, the comparison data between theory and experiment on pipe 1 for 60, 55, and 50 °C is obtained, namely 81.5%, 86.4%, and 92.5%

Table 6. Theoretical calculation results and the results of the ParallelFlow 2 Pipe Experiment

(°C)	Theory(°C)	Experiment(°C)
60	36.08	37.78
55	33.10	35.46
50	30,12	33.41

**Figure 5.** Comparison of Theory and Experiment on Pipe 2 Parallel Flow

In the table and graph above, the comparison data between theory and experiment on pipe 2 for 60, 55, and 50 °C is 95.2%, 92.8%, and 89.0%

Table 7. Theoretical calculation results and the results of the ParallelFlow 3 Pipe Experiment

(°C)	Theory(°C)	Experiment(°C)
60	56.56	42.42
55	52.49	42.76
50	48.07	43.08

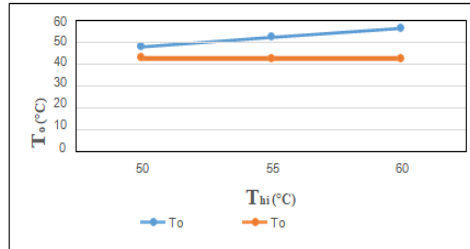


Figure 6. Comparison of Theory and Experiments on Pipe 3 Parallel Flow

In the table and graph above, the comparison data between theory and experiment on pipe 2 for 60, 55, and 50 °C is 75.0, 81.4%, and 89.6%.

b. Comparison of Counter Flow and Pararel Flow

In the discussion above, we obtain data from theoretical calculations on counterflow and pararellflow flows where the average value of counterflow flow is smaller than that of pararellflow flow. This can be seen in the graphic image below:

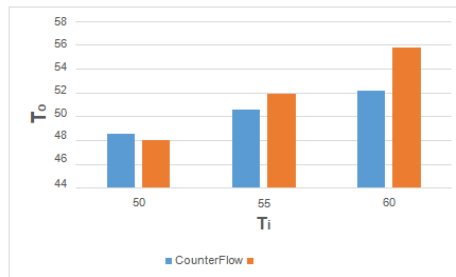


Figure 7. Comparison of Counter Flow and PararellFlow on 1 . pipe

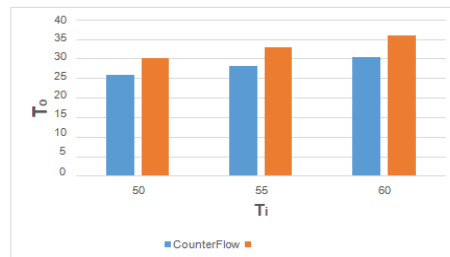


Figure 8. Comparison of Counter Flow and Pararell Flow on a 2. Pipe

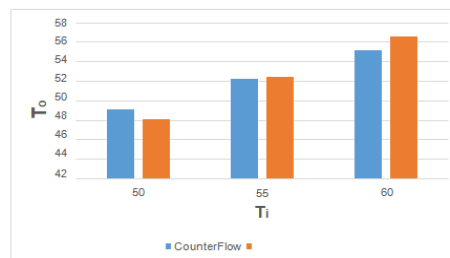


Figure 9. Comparison of CounterFlow and PararellFlow on a 3 . pipe

4. CONCLUSION

The temperature of the hot fluid coming out of the APK in the experiment tends to be higher than the temperature of the hot fluid coming out of the APK in the theoretical calculations of the mathematical modeling method. Meanwhile, the temperature of the cold fluid coming out of the APK in the experimental tends to be lower than the temperature of the cold fluid coming out of the APK in the theoretical calculations of the mathematical modeling method.

The average difference between theoretical and experimental calculations on counter flow flow in pipe 1 is 6.6%, in pipe 2 is 13.7%, and in pipe 3 is 15.5%. Meanwhile, the parallel flow in pipe 1 is 13.2%, pipe 2 is 7.6%, and pipe 3 is 18.0%.

In counter flow flow, pipe 1 and pipe 3 have a smaller difference between the theoretical calculation results and experimental results compared to parallel flow flow, but for pipe 2 counter flow flow has a greater difference between theoretical calculation results and experimental results compared to parallel flow.

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