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Research Article

Experimental Analysis of Copper Pipe and Steel Pipe in Shell and Tube Heat Exchanger

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Abstract:

In this thesis, the experimental analysis of two different systems was carried out by using copper tube and steel tube in shell and tube heat exchangers. The experimental systems were designed and manufactured to have the same physical properties in two types of heat exchangers. Manufacturing costs were noted to enable comparison.
In the system where the experiments were carried out, only the heat exchanger bodies were replaced and the analyses were carried out and the other systems were kept constant. In order to perform an efficient analysis of the efficiency, the inlet temperature of the heater water was kept constant and it was not exposed to any recirculation or heat loss. Although it was observed that the efficiency of the copper tube heat exchanger increased significantly when the inlet water temperature was high during the experiments, there was no significant difference in efficiency between the two heat exchangers at low temperatures.
As a result of these analyses, it has been concluded that if the heat transfer is to be carried out for low temperatures, considering the cost, the carbon steel tube heat exchanger can be used despite of the high thermal conductivity of copper.

1. Introduction

Heat exchangers are used to transfer thermal energy between two or more fluids or solid particles and a fluid at different temperature and thermal contact. The basic principle of a heat exchanger is that it transmits heat without transferring the fluid carrying the heat. There is no external thermal energy and work interaction in heat exchangers. Heat transfer mainly occurs due to conduction and convection [1-2]. In order to increase the efficiency according to the variety of the application, and at the same time, the width of the area to be used is effectively used by considering the possibilities of mechanical piping, taking into account the temperature change and the effect on the environment [3-5].
In previous studies, analyses were made from various aspects in order to increase the efficiency of heat exchangers, and in these studies, numerical analyses were made on the thermal hydraulic performance of three sets of shell and tube heat exchangers (STHEs) with different materials or different geometric tube layout patterns [6-15]. 30º, STHE_T), rotated triangle (60º, STHE_RT) and joined (STHE_C) patterns were performed. The results from solving the main continuity, momentum and energy equations showed that most of the heat transfer and pressure drop occurs during shell-liquid cross flow through the tube bundles. (Petinrin, M.O, Dare, A.A., 2015). The choice of size and material according to the needs in the design system are the main items in saving. In this study we have done, we have observed experimentally whether copper (111 W / m K @ 20 ^{0}C), which is a more thermal conductor, is always a correct alternative to a steel – EN10208 (42.2 W / m K @ 0 ^{0}C) material. The goal of this work is comparison of efficiency copper and steel pipe exchanger regarding to different temperatures and to guide for initial investment.

2. Classification of Heat Exchangers

Heat exchangers are devices that provide heat transfer between fluids at different temperatures, which we frequently encounter in today's industry, and where we can control the degree of these heat transfers, which we use effectively in areas such as chemistry, energy, food, and which are needed at points such as ventilation and air conditioning, heat storage.

2.1 Classification According to Construction Properties

The design and construction of this type of heat exchanger are generally categorized according to their construction characteristics.

2.1.1 Shell-Tube Heat Exchanger

In case-tube heat exchangers, which consist of a cylindrical body and parallel pipes placed in this body, one of the fluids flows through the pipes and the other flows through the body. Pipes or pipe bundle, body, heads on two heads, front and rear mirrors on which the pipes are fixed, and baffle plates or support rods that can support the pipes that direct the flow in the body are the elements of this heat exchanger type [16-18].
The standards of the construction of these heat exchangers have been determined by the tube heat exchanger manufacturers association, TEMA (Tubular Exchanger Manufacturers Association). The ability to meet the elongation that may occur due to pressure and temperature difference should be considered in the arrangements of fixed tube bundle heat exchangers. The recommended standard nominal pressures for the fluids used in the bodies and pipes of this type of heat exchanger are generally 2, 5, 6, 10, 16, 25 and 40 bar [19].

Figure 1. *Shell-Tube Heat Exchanger*

3. Results and Discussions

For the analysis of the experiments to be carried out to compare the effect of the thermal conductivity of the pipes on the results and the entry costs in the establishment of the system in the shell and tube heat exchangers, a system/setup shown in the figure 2.

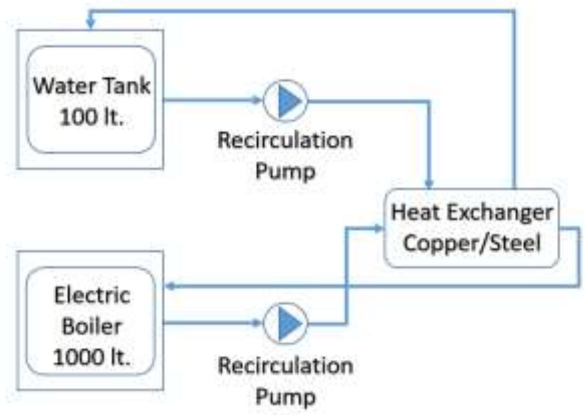

Figure 2. *Process Flow Diagram*

Here, in order to keep the temperature of the water entering the heat exchanger constant, we have supplied the inlet water with 1000 lt electric boilers in order to prevent any temperature change in 10 minutes. A circulation pump is used in order to circulate the hot water coming from the electric boilers in the heat exchangers. There is only one tank used for the same period of time for the storage and analysis of the water to be heated, and exactly 100 litres has been selected in this tank. Again, 1 circulation pump was used to circulate the water to be heated. During the experiments, a thermometer was added to the hot water inlet and outlet temperatures of the heat exchanger, and a thermometer was added to the inlet and outlet of the water to be heated, and the temperature controls were observed with digital displays. Except for the copper tube heat exchanger and steel tube heat exchanger used in the experiments, no mechanism has changed and the conditions have been observed equally. The heat exchangers are fixed with flanges on both sides with 4 bolts and nuts, only these parts are removed during the change and then their connections are provided. Heat exchanger specification is given in table 1.

Table 1. *Heat Exchanger Specification*

	Copper Heat Exchanger	Steel Heat Exchanger
Pipe Diameter (m)	0,0213	0,0213
Body Length (m)	0,51	0,51
Pipe Quantity (pcs)	9	9
Surface Area (m2)	0,0016	0,0016

4. Conclusions

Comparison of the results of the experiments at 50°C, 70°C and 90°C is summarized in the table 2.

The final temperature of the heated water specified here is the temperature of the water transferred from the heat exchanger to the tank.

Table 2. *Comparison of Experimental Analysis Results*

Heater Water Inlet Temp.	Copper Tube Heat Exchanger Final Temperature of Heated Water (10 min)	Steel Tube Heat Exchanger Final Temperature of Heated Water (10 min)
50°C	30,1°C	29,7°C
70°C	42,5°C	40,4°C
90°C	53,8°C	51,6°C

Considering the results, we see the temperatures of 30.1°C and 29.7°C when the final temperatures are taken into account in our experiment at 50°C, and we noted that the difference is 0.4°C.

In our experiment at 70°C, temperatures of 42.5°C and 40.4°C were determined, and the efficiency between these two heat exchangers was observed as 2.1°C, slightly different from 50°C.

In our experiment at 90°C, the difference between the temperatures of 53.8°C and 51.6°C was 2.2°C, although there was no significant difference from our previous experiment at 70°C, but it was not noticeable compared to that at 50°C. We concluded that there was a noticeable change.

After these comments, we came to the conclusion that there are no serious differences in the setups where the inlet temperature of the heating water is low, but that the difference is even wider in the environments where the temperature of the heating water increases.

When we compare the entrance cost and the test results as a whole, the temperature of the heating water is low and the temperature of the water desired to be heated is very high, there is almost no temperature difference, and the entrance cost is high in the copper tube heat exchanger. It has been concluded that choosing the tube heat exchanger is not correct.

At higher temperatures, the yield that can be obtained should be analysed much better and then a selection should be made, and it should be paid attention to how long it takes to get the return of the yield to be obtained.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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