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Research Article

Influence of Fluid Inflow Rate on Performance Effectiveness of Shell and Tube Type Heat Exchanger

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Abstract

In industrial processes, heat exchangers are needed to transfer a certain amount of heat energy from the system to the environment. The research object observed using a heat exchanger type 1- 2 shell and a tube was water in hot and cold fluids. It aimed to determine the relationship between hot and cold fluids and the heat transfer coefficient, fouling factor, and tool efficiency. The research method varied the hot water by 50, 70, 90, 100 mL/s and the cold water by 20, 40, 60, 80 mL/s. After getting the data for each fluid's inlet and outlet temperatures, the effectiveness analysis was calculated. The research results on the hot fluid variable demonstrated that the more the fluid was flowing into the shell, the higher the heat transfer coefficient, heat transfer velocity, and average effectiveness. Meanwhile, the fouling factor tended to decrease along with the increasing hot fluid. The cold fluid variable, the higher the cold fluid flows into the tube, the higher the heat transfer coefficient and the average heat transfer velocity. Furthermore, the fouling factor and effectiveness tended to decrease along with the increasing cold fluid flow.

Keywords: *Heat exchanger, shell and tube, effectiveness analysis, fouling factor, heat transfer coefficient.*

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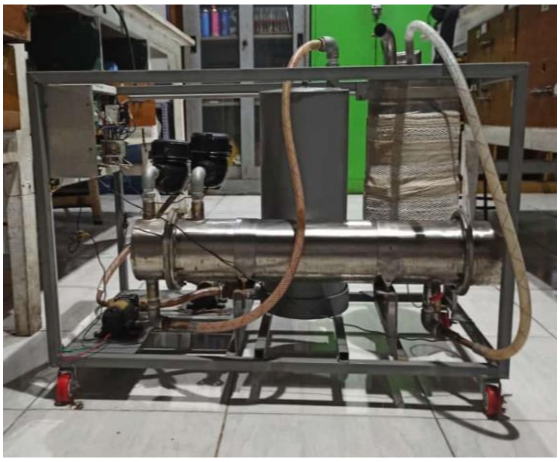
INTRODUCTION

The increasing growth in the industrial sector causes humans to innovate in creating tools to support the production process. One example of such equipment is a heat exchanger, which is used to transfer a certain amount of heat energy from the system to the environment in industrial processes[1,2]. The heat exchanger is a device used to transfer the heat energy of two or more fluids. Almost all industries use heat exchangers in their industrial processes, such as the paper industry, food industry, chemical industry, power generation industry, gas industry, oil refinery, and wood industry. A heat exchanger utilizes heat energy from a fluid to heat another fluid without changing the phase, thereby providing two benefits at once, namely cooling the hot fluid and heating the cold fluid. The choice of shell and tube type heat exchanger as the subject of this discussion is because it has various capacities and sizes that are easily found on the market, the construction is relatively cheap, can cause a small ratio of heat transfer to volume and mass of fluid, easy to clean, suitable for condensation or boiling heat[3,4].

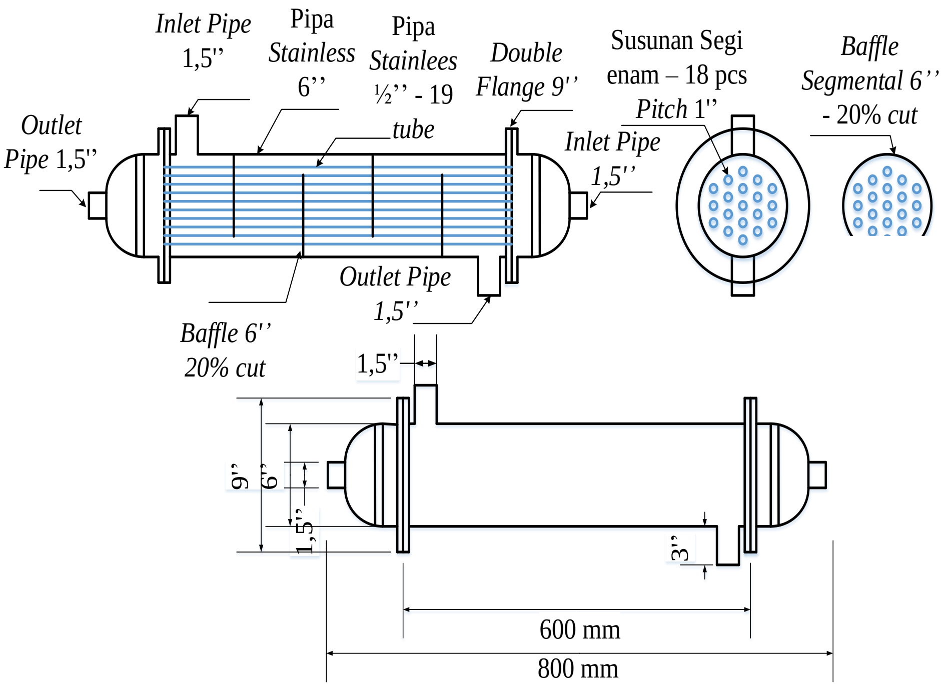
Transfer and pressure drop can be varied according to the capacity of the heat exchanger, can reduce thermal stress, material and materials can be varied, and maintenance is more accessible. In a previous study, [5] investigated the effect of flow rate on the effectiveness of heat exchangers using a shell and tube type 1-2 heat exchanger, the fluid in the shell is the oil with a flow rate of 0.000167 m^3/hour and the fluid in the tube is water at a rate of 0.000167 m^3/hour. volumetric rate 0.0000833 m^3/hour. The results of the research conducted by [5] found that the fluid flow rate dramatically affects the tool's performance. If the fluid rate is too small, it will cause obstacles on the inlet and outlet sides of the device due to the fouling factor. The fouling factor will cause a decrease in the rate of heat transfer, causing a reduction in the performance and effectiveness of the tool. Therefore, in this study, several updates were carried out, namely the use of stainless steel material in the shell and tube, varying the fluid flow rate which is not too small to reduce the risk of obstacles and fouling factors considering that shell and tube heat exchangers have small diameter tubes[6,7]. So it is necessary to increase the fluid flow rate and change the type of fluid used in the form of cold water (30°C) on the shell and hot water (70°C) on the tube. One of the efforts to improve the performance of the heat exchanger is to perform simulations with computations[8–10]. With this previous research update, it is hoped that it will be able to improve the performance of the heat exchanger.

METHODS AND ANALYSIS

In this research, the material used as a hot fluid and cold fluid is water. Various variables are the flow rate of hot fluid, and cold fluid, which is 50, 70, 90, 100 mL/s and the flow rate of cold fluid in the form of water is 20, 40, 60, 90 mL/s.The equipment used is a shell and tube type heat exchanger which is shown in Figure 1 and the specifications for the tool are presented in Table 1.



a. Research Tools



b. Heat Exchanger Design

Figure 1. a) Research Tools, b) Heat Exchanger Design.

Table 1. Research Tool Specifications

Parameter	Specification
Shell And Tube Type	1-2 *Exchanger*
Shell & Tube Material	*Stainless Steel*
Inlet & Outlet Pipe	1,5 Inch
Shell Length	80 Cm
Number of Tubes	18 Pieces
Pitch Type	*Triangular Pitch*
Shell Fluid	water (70°C)
Fluid Tube	water (30°C)

RESULTS AND DISCUSSIONS

From the research that we conducted, we obtained data from various variables of hot and cold fluid flow rates as follows:

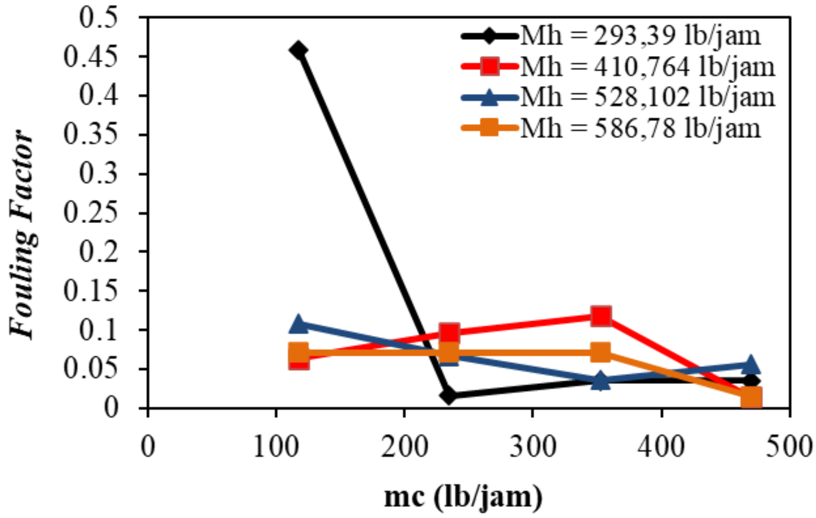


Figure 2. Graph of Velocity Effect on Fouling Factor

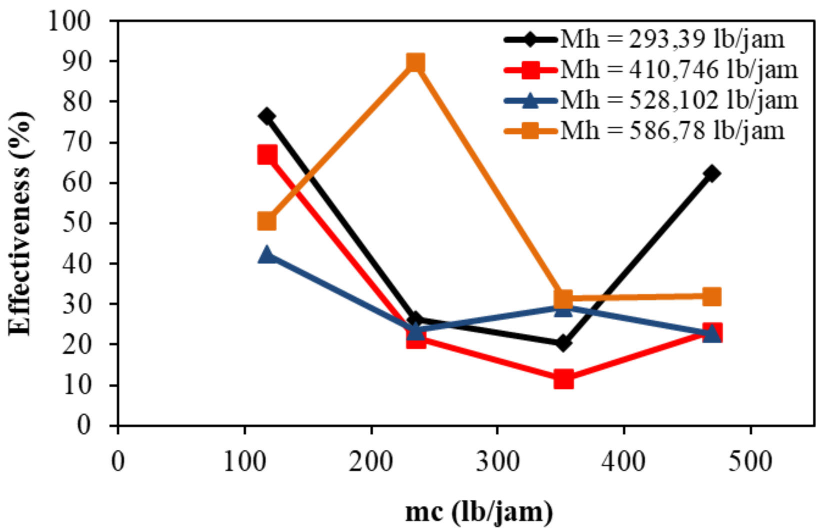


Figure 3. Graph of the Effect of Velocity on Effectiveness (Ɛ)

Effect of Fluid Flow Rate on Fouling Factor

Based on Figure 2, it is known that the fouling factor value tends to decrease along with the increase in the fluid flow rate. According to research conducted by [11,12], it is said that the fouling factor will increase if the fluid flow rate is minimal. In their international journal, [13,14] proved by research that heat transfer also increases and the fouling rate decreases with an increase in fluid flow velocity. Thus, the fluid flow velocity with the fouling factor is inversely proportional. Figure 2 has proven the existing theory. However, there was an inconsistent increase and decrease in the fouling factor value at several points. The irregular decrease and increase occurred due to several external factors that caused data collection errors. Based on Figure 2, the velocity of the cold fluid is 117,356 lb/hour, and the hot fluid is 293.39 lb/hour, which shows the maximum fouling factor value of 0.458. At this speed, there is quite a large amount of impurities in the shell and tube type heat exchanger, which obstructs fluid flow, so that the heat transfer that occurs is less than optimal. It is necessary to increase the flow velocity of hot and cold fluids to reduce the value of the fouling factor. Meanwhile, the minimum fouling factor value is at a cold fluid velocity of 469.424 lb/hour and a hot fluid velocity of 410.746 lb/hour, 0.014. At this speed, the impurities formed are pretty low, so that the incoming fluid flow is not hampered and the heat transfer process is maximized.

Effect of Fluid Flow Rate on Effectiveness (ε)

In Figure 3. b, it can be seen that there was an inconsistent increase and decrease. The optimal effectiveness is at the cold fluid flow velocity of 234.712 lb/hour and the hot fluid flow velocity of 528.102 lb/hour, 77.58%. In their research, [15,16] said that in the shell section of a shell and tube type heat exchanger, the value of the effectiveness of the tool will be more significant along with the considerable flow rate of the flowing fluid. This is because the fluid flowing in the shell undergoes a breakdown. Flow by the baffle, thereby increasing the Reynolds number and accelerating the transfer of momentum, so the effectiveness value is high. In the tube section, the value of the point of the tool is more significant when the fluid flow rate is low, and this is because a high fluid flow rate will reduce the contact time of the fluid in the tube, so the heat transfer process is getting shorter. In addition, in their research, [12,17,18] also prove that the effectiveness will decrease drastically and increase fluid mass flow on the tube side. In this statement, it can be seen that the effectiveness of the tool decreases along with the increase in the velocity of the fluid flow in the tube and in this study, the tube part is flowed by cold fluid, so the results shown in Figure 6. b is by the applicable theory. The minimum effectiveness value is at the cold fluid flow velocity of 117.356 lb/hour and the hot fluid flow velocity of 293.39 lb/hour, 18.71%. This speed is an inefficient condition in heat transfer events because of the inability to transfer heat, so it takes a long time.

CONCLUSIONS

The average effectiveness tends to increase in the flow of hot fluid and cold fluid flowing in the shell. In comparison, the fouling factor tends to decrease along with the increase in hot fluid and cold fluid so that the effect of hot fluid flow rate on the fouling factor is inversely proportional.

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DECLARATION OF CONFLICTING INTERESTS

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