ANALYISIS OF THE EFFECT OF HEAT INLET VELOCITY ON CROSSFLOW FOR CHARACTERISTICS OF HEAT EXCHANGER SHELL AND TUBE

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ABSTRACT

The effect of the velocity (V) of the opposite flow and the temperature of the hot fluid inlet (Thi) on the characteristics of the shell and tube heat exchanger has been investigated with forced convection heat transfer and is applied to the design of oil coolers in aircraft, power generation units and others. The test model is modified with hot fluid (oil) on the tube side and cold fluid (water) on the shell side. Experimental research was carried out with variations in velocity (V) = 0.011 to 0.037m / s and hot fluid inlet temperature (Thi) = 363K to observe the characteristics of the heat exchanger along with increasing velocity (V) with a significant increasing gradient. The results of experimental research show that the increase in velocity (V) <0.037 m / s with the heat fluid intake temperature (Thi) 363 K, the heat exchanger characteristics increase, namely; Redh number is 23.29%, Nudh number is 34.52%, hi is 34.80%, Redc number is 28.36%, Nudc is 36.95%, ho is 36.78%, U is 34.83%, q is 22.56% while efficiency (ε) is 71.79% at a speed (V) <0.024 m / s and a decrease in speed (V)> 0.024 m / s of 24.99
Keywords : Analysis, Effect, Velocity, Heat Fluid

INTRODUCTION

A heat exchanger is a device used for heat transfer between two fluids, both of which have a temperature gradient and are separated by a wall [1]. Many types of heat exchangers are made and used in power generation centers, heating room systems, air conditioning, chemical processing systems and others. One type of heat exchanger that is often used in industrial engineering applications is the shell and tube type.

The classification of fluid flow arrangements of the shell and tube type consists of direct flow (parallel flow), counter flow (counter flow) and cross flow (cross flow) [2]. Shell and tube type heat exchanger counter flow (counter flow) hot fluid flows in the pipe (tube) and cold fluid flows in the shell. The cold fluid enters in the opposite direction to the inlet of the hot flow as well as the outflow.

Heat exchanger effectiveness is better when hot air flows on the tube side and cold air on the shell side [3]. This is because the hot air density is lower, the heat convex coefficient is high, while the area is not enlarged. For that hot air must flow at high speed (on the side of the tube). From Ekadewi's experiment, the authors conducted a heat exchanger experiment using water fluid which would flow on the shell side and oil fluid which would flow on the tube side. Having 8 tubes with a diameter of 3/8 inch, the mass flow rate of cold flow on the shell side is made opposite the mass flow rate of hot fluid on the side of the tube [4]. This is done to see the effect of the opposite mass flow rate in heat transfer between heat flow and cold flow [5].

METHOD

Research Variables

The research variables are divided into independent variables, namely velocity (V) and heat fluid intake temperature (Thi) and the dependent variable, namely the characteristics of the shell and tube heat exchanger, namely: Reynolds number, Nusselt number, Prandtl number, convection coefficient h, overall heat transfer coefficient U , Heat transfer rate q, efficiency ε.

Data Collection Techniques

To measure the temperature at a number of points, a T-type thermocouple (Chromel-Alumel) is used which is connected to the CE 307 brand Display Temperature after going through the 4 channel selector. The placement of the measuring points of the mean shell temperature is obtained from the four measurement points. To find out the incoming hot fluid (Thi), the thermocouple is placed on the shell entry pipe. Meanwhile, the temperature of the fluid after passing through the tube is measured by placing the thermocouple in the fluid pipe that will return to the tank. Likewise, to measure the temperature of the incoming cold fluid (Tci), the thermocouple is placed in the cold fluid inlet shell. And the temperature of the fluid after passing through the shell is measured by placing the thermocouple on the exit fluid shell, as shown in Figure 1.

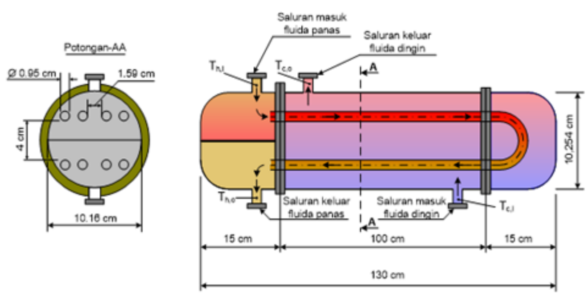


Figure 1. Dimensions and Measurement Locations

Data Analysis Techniques

After the research data has been collected, it will then be analyzed using multiple regression to obtain the characteristics of forced convection heat transfer.

DISCUSSION

Research Data

Experiments were carried out by varying the velocity (V), namely 0.011 m / s - 0.037 m / s with Thi kept constant at a temperature of 363 K. The data were taken after the system was in steady state. A steady condition is reached when the fluid velocity (V) and the temperature of the hot fluid inlet (Thi) no longer experience significant or constant fluctuations. At steady conditions, the respective temperatures are recorded: hot fluid inlet temperature (Thi), hot fluid exit temperature (Tho), cold fluid inlet temperature (Tci) and cold fluid exit temperature (Tco), the following data are obtained.

Graph Analysis

Heat Intake Fluid Analysis

The increase in Reynold's number (Redh) does not mean that it occurs at V <0.024 m / s with a sloping increment gradient, while at V> 0.0.24 K the increase in Reynold's number (Redh) is significant with a steep increment gradient. The lowest Reynold number (Redh) at V = 0.011 m / s and the maximum Reynold number (Redh) at V = 0.037 m / s for each velocity variation, Figure 2.

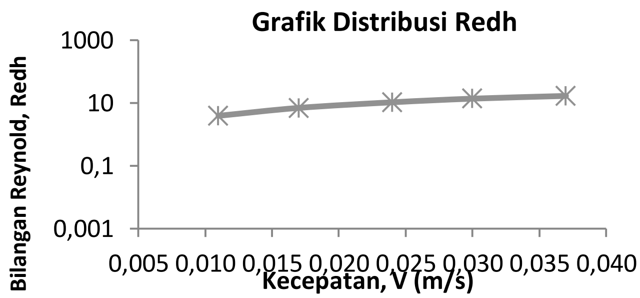


Figure 2. Graph of the distribution of Redh as a function of T_{hi}

This is related to the temperature of the average hot fluid which has increased so that it increases the fluid velocity (V), which causes the mass flow rate of hot fluid to increase, this is also in accordance with the Reynold number equation where Reynold's number is directly proportional to the mass flow rate of hot fluid ((mh) ̇).

Figure 3, The increase in the Nusselt number (Nudh) means that it occurs at V <0.017 m / s with a steep increment gradient, while at V> 0.017 m / s the increase in the Nusslet number (Nudh) is meaningless with a sloping increment gradient. The lowest Nusselt number (Nudh) is at V = 0.011 m / s and the maximum Nusselt number (Nudh) is at V = 0.037 m / s for each velocity variation (V).

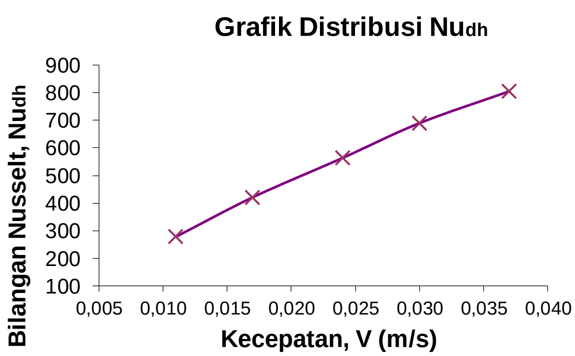
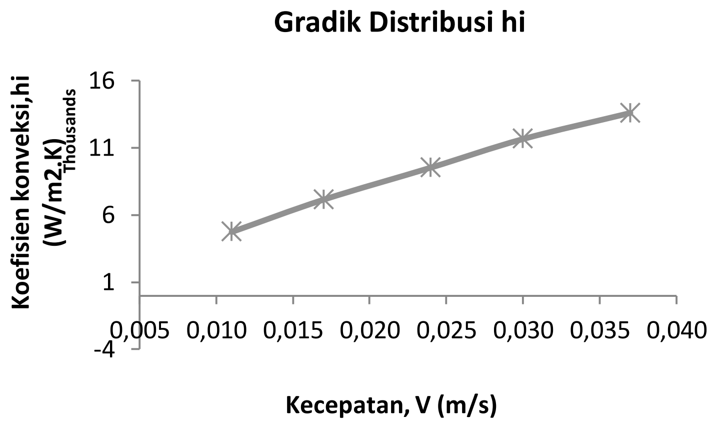


Figure 3. Graph of Nudh distribution as a function of T_{hi}

This is related to the temperature of the average hot fluid which has increased so that it increases the fluid velocity (V), which causes the Reynold number to increase so that the Nusselt number also increases, this is in accordance with the Nusselt number equation where Reynold's number is directly proportional to the Nusselt number (Nudh). The experimental results show that the greater the fluid velocity (V) with constant heat inlet temperature (Thi), the greater the convection coefficient (hi) conditions occur at the overall velocity (V) as shown in Figure 4.



Cold Fluid Analysis

The experimental results show that the greater the fluid velocity (V) with constant hot fluid intake temperature (Thi), the greater the Reynold number (Redc), the condition occurs for the overall velocity variation (V), Figure 5.

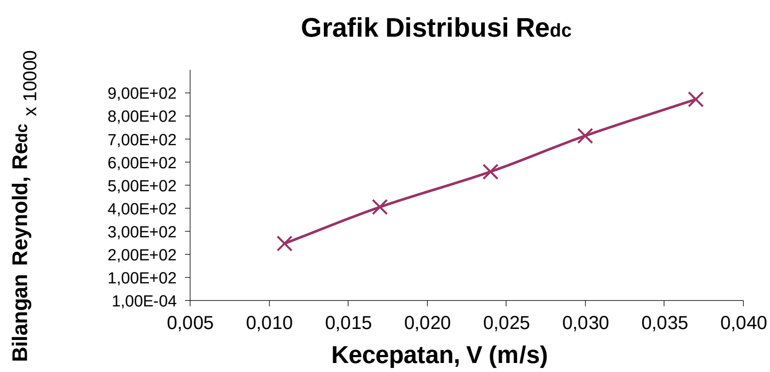


Figure 5. Graph of the Redc distribution as a function of Thi

This is related to the temperature of the average cold fluid which increases with the increasing speed of the fluid (V), which causes the mass flow rate of cold fluid to increase, this is in accordance with the Reynold number equation where Reynold's number is directly proportional to the mass flow rate of cold fluid. The experimental results show that the greater the velocity of the fluid (V) with the constant temperature of the hot fluid (Thi), the greater the Nusselt (Nudc) number, the conditions occur for the overall velocity variation (V), Figure 6

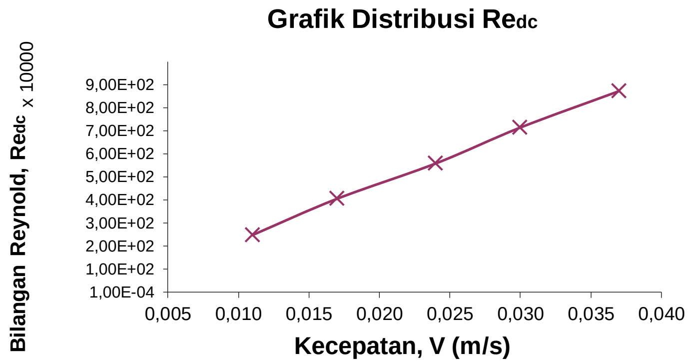


Figure 6. Graph of the Nudc distribution as a function of Thi

This is related to the temperature of the average cold fluid which has increased with increasing fluid velocity (V), which causes the Reynold number to increase so that the Nusselt number also increases, this is also in accordance with the Nusselt number equation where Reynold's number is directly proportional to the Nusselt number (Nudc). The experimental results show that the greater the fluid velocity (V) with constant hot fluid intake temperature (Thi), the greater the convection coefficient (ho) the condition occurs for the overall velocity variation (V), Figure 7.

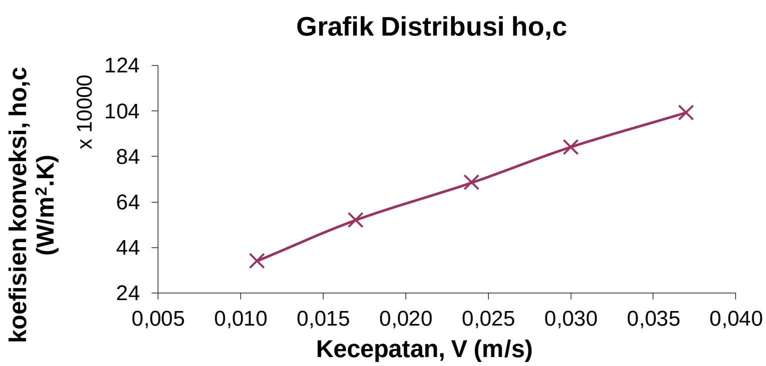


Figure 7. The graph of the ho distribution as a function of Thi

This is related to the temperature of the average cold fluid which has increased with the increasing fluid velocity (V), which causes the Reynold number, the Nusselt number so that the convection coefficient also increases, this is also in accordance with the equation of the convection coefficient number where the convection coefficient is directly proportional to Nusselt number (Nud, c) ,.

Analysis of the Total Transfer of Food Coefficient

The experimental results show that the greater the fluid velocity (V) with constant heat fluid inlet temperature (Thi), the greater the overall heat transfer coefficient (U) conditions occur for the overall velocity variation (V). The increase in overall heat transfer coefficient (U) is insignificant at V> 0.017 m / s with a sloping increase gradient, while at V <0.017 m / s the increase in total heat transfer coefficient (U) is significant with a steep increment gradient. The lowest overall heat transfer coefficient (U) is at V = 0.011 m / s and the optimal overall heat transfer coefficient (U) is at V = 0.037 m / s for each velocity variation (V). The maximum total heat transfer (U) at Thi = 363 K for each variation of the temperature of the hot fluid inlet (Thi).

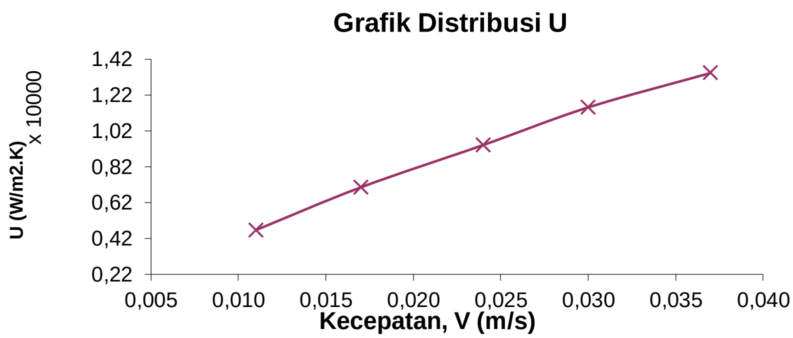


Figure 8. Graph of U distribution as a function of T_{hi}

This is related to the temperature of the average cold and hot fluid which has increased with the increasing velocity of the fluid (V), which causes the Reynold number, Nusselt number, the convection coefficient to increase so that the overall heat transfer coefficient (U) also increases,

Heat Transfer Rate Analysis

The experimental results show that the greater the fluid velocity (V) with constant heat fluid inlet temperature (Thi), the greater the heat transfer rate (q) conditions occur for the overall velocity variation (V) Figure 9.

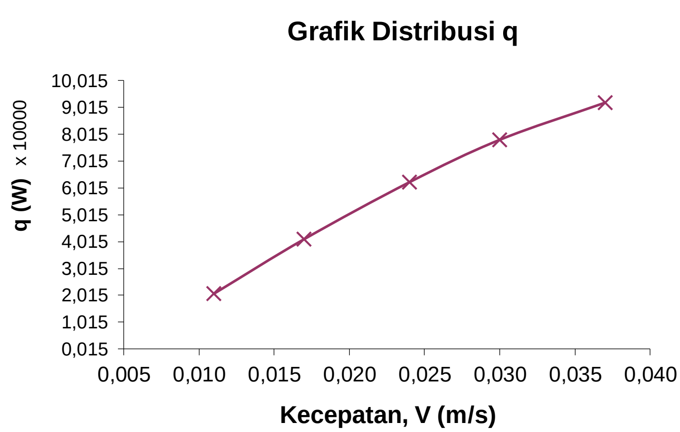


Figure 9. Graph of distribution of q as a function of Thi

The increase in heat transfer rate (q) is quite significant at V <0.017 m / s and V> 0.024 m / s with a steep gradient, while at 0.017 m / s <V <0.030 m / s, the increase in heat transfer rate (q) is insignificant with a gentle increment gradient. The lowest heat transfer rate (q) is at V = 0.011 m / s and the optimal heat transfer rate (q) is at V = 0.037 m / s for each variation of the hot fluid inlet temperature (Thi).

Analysis of Heat Exchanger Effectiveness

The experimental results show that the greater the fluid velocity (V) with constant hot fluid intake temperature (Thi), the smaller the effectiveness (ε) conditions occur at the overall velocity (V), Figure 10.

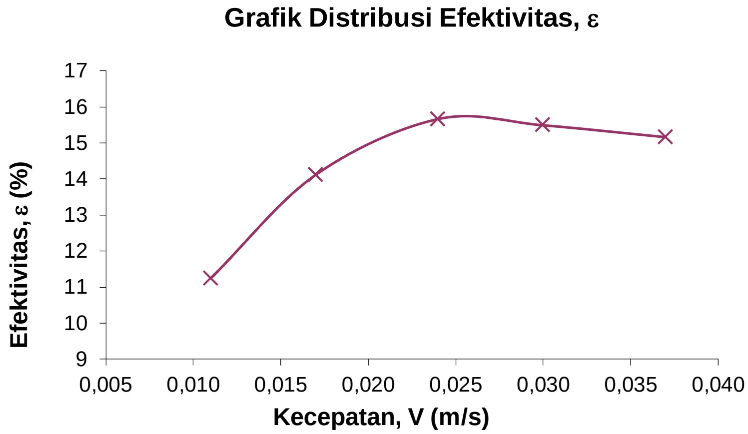


Figure 10. The distribution graph of ϵ as a function of Thi

Significant decrease in effectiveness (ε) occurs at V> 0.024 m / s with a steep slope gradient, while at V <0.024 m / s, the increase in effectiveness (ε) is not significant with an increasing slope gradient. The lowest decrease in effectiveness (ε) is at V = 0.024 m / s and the maximum heat transfer rate (q) is at V = 0.011 m / s for each variation of the hot fluid intake temperature (Thi).

CONCLUSION

According to the results of research conducted by varying the fluid velocity (V), namely 0.011 m / s to 0.037 m / s with a constant heat fluid intake temperature (Thi) of 363 K to the characteristics of the shell and tube heat exchanger, the conclusion is that the characteristics of the heat exchanger the maximum heat is found at the fluid velocity (V) <0.037 m / s with each increasing rate; for Re, dh is 23.29%, Nu, dh is 34.52%, hi is 34.80%, Re, dc is 28.36%, Nu, dc is 36.95%, ho is 36.78%, U is 34.83%, q is 22.56% while ε amounted to 71.79% then decreased by ε by 24.99%.

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