Comparison of heat transfer coefficient on single tube and multi tube heat exchanger

To cite this article: Ikhwan Permana et al 2019 J. Phys.: Conf. Ser. 1153 012138

View the article online for updates and enhancements.
Comparison of heat transfer coefficient on single tube and multi tube heat exchanger

Ikhwan Permana, Tri Ayodha Ajiwiguna and Mukhammad Ramdlan Kirom
Engineering Physics Department, Telkom University, Jl. Telekomunikasi, Jl. Terusan Buah Batu No.01, Sukapura, Dayeuhkolot, Bandung, Jawa Barat 40257 INDONESIA

E-mail: triayodha@telkomuniversity.ac.id

Abstract. Heat exchanger (HX) is a device that provides heat exchange between two fluids that have temperature difference. Heat exchanger is widely applied to industrial process, power plant, transportation, air conditioning and refrigeration. In this study, the heat transfer coefficient between single tube and multi tube with the same heat transfer surface area are compared. The dimension of single tube heat exchanger is 40 cm length with 9.5 cm diameters. On the other hand, the multi tubes heat exchanger consists of ten tubes with 0.95 diameters and 40 cm length. These heat exchangers are submerged in low temperature water and the ambient air is streamed by fan with 0.0032 kg/s, 0.0026 kg/s, and 0.002 kg/s of mass flow rate. The experiment is performed for two hours. The temperature of ambient, outlet air, and water are recorded using T-type thermocouple. The heat transfer coefficient are then analyzed. The result shows that heat transfer coefficient of multi-tubes heat exchanger are 26.6% higher than single tube heat exchanger.

1. Introduction
Heat exchanger (HX) is a device that provide the transfer of thermal energy between two or more fluids at different temperatures [1-3]. HX is widely applied to a process, power plant, transportation, air conditioning and refrigeration [4-6]. Shell and tube is HX that classified according to its construction design, which shell is outer frame and tube is a pipe inside the shell. The tube is one part that have an important role in HX, where heat is exchanged between two fluids trough a pipe wall. In general, HX performance can be rated from its the heat transfer coefficient (U), surface area (A), and pressure drop (dP) [7-8]. It has been studied that the amount of heat exchange in HX is directly proportional to the required surface area [8]. In this study, comparing the heat transfer coefficient on single tube and multi tube heat exchanger with the same surface area is performed by using log mean temperature difference method.
2. Experimental Methods

![Data measurement Scheme](image)

**Figure 1.** Data measurement Scheme

In this experiment, the experimental scheme is shown in Figure 1. The tubes were submerged in the low temperature water. Ambient air was streamed through the tubes by using fan. Temperature measurement were performed at outlet air, inlet air and water. Temperature data logger was utilized to record each temperature every ten second. The temperature sensor was T-type thermocouple which connected directly to the temperature data logger. Hot wire was used to measure the air velocity on the HX.

The mass flow rate of air was calculated by:

\[ \dot{m} = \rho A v \]  

where \( \rho \) is the air density, \( A \) is the cross sectional area, and \( v \) is the velocity of air.

Heat transfer rate on the HX was then calculated by:

\[ \dot{Q} = \dot{m} c \Delta T \]  

where \( \dot{m} \) is mass flow rate of air, \( c \) is specific heat of air and \( \Delta T \) is temperature difference between ambient temperature and output temperature of air. Once the heat flow rate was calculated, the U value was estimated by equation 3 and 4.

\[ U = \frac{\dot{Q}}{A_s \Delta T_{lm}} \]  

\[ \Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{ln \frac{\Delta T_1}{\Delta T_2}} \]  

where \( A_s \) is heat transfer surface of the tubes and \( \Delta T_{lm} \) (logarithmic mean temperature difference), \( \Delta T_1 \) is the temperature difference in the ambient temperature with the initial temperature of water, \( \Delta T_2 \) is the difference in the temperature of the output air at the outlet tube with water temperature that has received heat transfer.
3. Result and discussion

3.1. Experiment at 0.0032 kg/s mass flow rate

Figure 2. Graph of U value with time at 0.0032 Kg/s mass flow rate

Figure 2 shows the U value versus time during the experiment with air mass flow at 0.032 kg/s. U value on multi tube tends to decreases while on single tube increases. U value on multi tube at the begin is 0.017 W/(m².K), and ends at 0.008 W/(m².K). U value single tube at the begin is 0.001 W/(m².K), and ends at 0.011 W/(m².K). The highest point of U value on multi tube is 0.019 W/(m².K), while on single tube is 0.0117 W/(m².K). The average of U value during experiment on multi tube is 0.013 W/(m².K), and 0.0105 W/(m².K) on single tube; there is 0.0025 W/(m².K) difference, so U value on multi tube 23% higher than single tube.

3.2. Experiment at 0.0026 kg/s mass flow rate

Figure 3. Graph of U value with time at 0.0026 Kg/s mass flow rate
Figure 3 shows the U value of HX with mass flow rate of air is 0.0026 kg/s. Curves is still similar with previous experiment. The U value on multi tube at the begin is 0.014 W/(m².K), and ends at 0.011 W/(m².K), while on single tube begin at 0.0099 W/(m².K), and ends at 0.0102. The highest point of U value on multi tube is 0.0168 W/(m².K), while on single tube is 0.0116 W/(m².K). The average of U value during experiment on multi tube is 0.0125 W/(m².K) and 0.0098 W/(m².K) on single tube. There is 0.0027 W/(m².K) difference, or U value on multi tube 27.5% higher than single tube.

3.3. Experiment at 0.002 kg/s mass flow rate

Figure 4 shows the result of U value with the mass flow rate at 0.02 kg/s. It this experiment the U value of multi tubes curve is more stable than two previous graph. The U value on multi tube begin at 0.0125 W/(m².K) and ends at 0.0103 W/(m².K), while on single tube begin at 0.0102 W/(m².K), and ends at 0.0093. The maximum U value on multi tube is 0.0135 W/(m².K), while on single tube is 0.01 W/(m².K). The average U value during experiment on multi tube is 0.0115 W/(m².K), while on single tube is 0.00889 W/(m².K). There is 0.0022 W/(m².K) difference, which is on multi tube 29.5% higher.

Table 1. U value result on each mass flow rate

| mass flow rate | mass flow rate | mass flow rate |
|----------------|----------------|----------------|
| Single tube (W/(m².K)) | 0.0105 | 0.0098 | 0.00889 |
| Multi tube (W/(m².K)) | 0.013 | 0.0125 | 0.0115 |

Based on the calculation of the average U value, Table 1 shows the comparison between multi tube HX and single tube HX. The U value increased while the air mass flow rate increased [9]. The multi tube HX has averagely 26.6% higher U value than single tube.
4. Conclusion
The comparison of U value between multi tube and single tube with same surface area has been studied in this study. Based on the experiment the U value of multi tube HX has 26.6% higher than single tube HX.

5. References
[1] Sadik K, Hongtan L and Anchasa P 2002 Heat Exchanger: Selection, Rating and Thermal Design CRC Press p. 1
[2] Ekadewi A H 2001 Pengaruh Kecepatan Aliran Terhadap Evktivitas Sheel and Tube Heat Exchanger jurnal teknik mesin vol. 3 no.2
[3] Yunus A. C 2004 Heat Transfer: A Practical Approach 2nd ed New York: McGraw-Hill p. 886
[4] R K Shah, D P Sekulic 2003 Fundamental of Heat Exchanger Design, New Jersey John Wiley & sons Inc p. 3
[5] D aquaro, M pieve 2007 High Temperature Heat Exchangers for Power Plants: Performance of Advance Metallic Recuporators Elsevier vol. 27 p. 389–400
[6] Firouzfar E, Soltanieh M, Hossien N, S and Saidi M 2011 Application of heat pipe heat exchangers in heating, ventilation and air conditioning (HVAC) systems Scientific Research and Essays 6. 1900-1908.
[7] Rifnaldi V, Totok R B and Gunawan Nugroho 2014 Optimasi Desain Heat Exchanger Shell-and-Tube Menggunakan Metode Particle Swarm Optimization Jurnal Teknik Pomits vol. 3 no. 2
[8] Yasunaga T, Noguchi T, Morisaki T and Ikegami Y 2018 Basic Heat Exchanger Performance Evaluation Method On Otec Journal Of Marine Science And Engineering 6. 32
[9] Basri 2011 Analisis Pengruh Laju Aliran Massa Terhadap Koefisien Perpindahan Panas Rata-Rata Pada Pipa Kapiler di Mesin Refigrasi Focus 808 Jurnal Mekanikal vol.2 no.1