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Feasibility Study on Performance of Heat Exchanger-001 Refinery in *Pusat Pengembangan Sumber Daya Manusia Migas Cepu*

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Abstract. *PPSDM Migas Cepu* is one of oil and gas industry in Indonesia. Their process requires Heat Exchanger for pre-heating purposes. The Heat Exchanger cannot work optimally because of the impurities attached to the walls shell and tube. Sometime the impurities attached to the walls of shell and tube, so it makes can't work optimally of this industry. For that reason, the purpose of this calculation is to find out the heat efficiency during the process. Heat efficiency is the ratio of the amount of heat that moves from a high temperature fluid to a lower temperature fluid in a certain time unit which can show the performance of a Heat Exchanger. The result show that the clean overall coefficient (Uc) and design overall coefficient (Ud) are 7,4301 Btu/ft^2.jam.^{o}F and 7,2517 Btu/ft^2.jam.^{o}F. For dirt factor (Rd) are 0,0033 ft^2.jam^{o}F/Btu. The Pressure Drop are 0,0448 Psi for Tube and 0,0035 Psi for Shell. The value of the Heat Efficiency are 82,3840 %. Which mean according to the results of these parameters, it can be concluded that the Heat Exchanger-001 is still possible to operate.

Keyword: Heat Exchanger, efficiency heat, shell and tube.

1. Introduction

Sources of oil in Indonesia include quite a lot spread over several areas, one of which is in the Cepu area, Blora Regency, Central Java. It was first discovered by an engineer from the Netherlands named Andrian Stoop in 1886. The Cepu area is located on the border between Central Java and East Java. Judging from the history of PPSDM MIGAS (Centre for Human Resource Development for Oil and Gas) formerly known as the Oil and Gas Education Center and Training Center, it has undergone several name changes since the discovery of the oil in Cepu until now. [1]

The use of heat exchangers is increasingly being used in various industries to lower and raise temperatures to meet the technical needs of various products. Industries that use heat exchangers such as the chemical industry, factories, office buildings, hospitals and power plants. [2]. Heat exchanger is a tool that plays an important role in oil and gas processing in an industry. The heat exchanger works as a pre-heater for the feed before being heated higher in the furnace. Apart from being a preheater, the heat exchanger also functions to lower the temperature of a product before entering the next process. The heat exchanger is very influential on the success of an oil refinery, the heat transfer process is very important in the context of energy conservation, process requirements, safety requirements and environmental protection. Therefore, the performance evaluation of the heat exchanger is curie out to determine the value of the work efficiency of the heat exchangers hoped that through this efficiency calculation, the heat exchanger is still feasible to operate.

A heat transfer device is considered to be able to function properly in its use if it meets the requirements, namely being able to transfer heat according to the needs of the operating process in a dirty state (fouling factor or Rd). Usually the heat exchanger is calculated for the dirt factor after several periods. If the period is approaching, the heat exchanger cannot work optimally due to the presence of impurities attached to the shell and tube. This can be overcome by temporarily stopping the heat exchanger and then cleaning the heat exchanger. The definition of Rd is the maximum combination of heat transfer required by dirt attached to the surface of the shell and tube if not cleaned will reduce the heat transfer that occurs. [3]

Based on research conducted by Jajat Sudrajat [4] the effectiveness value was 37.4% on the Heat Exchanger shell & tube with COG Booster. While research conducted by Chandra, et al [5] the effectiveness value obtained on heat exchangers using 4 baffles is 43%. The effectiveness value obtained in the study by Muhammad Rais, et al [6] was 76.06% on the heat exchanger with the Kern method. Then in a study conducted by Ahmad, et al [7] obtained an effectiveness value of 47.77% on the heat exchanger. In heat exchanger using baffles 15 cm apart, the effectiveness value is 82.13% in a study conducted by Gede, et al [8]. And the research conducted by Aznam, et al [9] scored the effectiveness on the heat exchanger shell and tube type BEM by 70%.

At the Cepu Oil and Gas PPSDM Refinery, there are 5 heat exchangers. For HE-001 (Heat Exchanger 001) it receives diesel products produced from HE-002 and is used as a pre-heater to heat crude oil before being heated again in the furnace, so that furnace does not require a lot of fuel to heat crude oil and cooler to cool the diesel is not too heavy. There are several types of heat exchangers commonly used, namely Double Pipe, Shell and Tube and Cross Flow Exchangers, for the Cepu Oil and Gas PPSDM Oil Refinery the type used is Shell and Tube. The advantages of shell and tube heat exchangers are that they have high efficiency, have a large surface area at a small volume size, require minimal space and are easy to maintain and easily adapt to almost all types of liquid chilling. [10]

In this case study, the purpose of the calculations carried out is to determine the heat efficiency during the industrial process.

2. Research Methods

To determine the efficiency of the Heat Exchanger, this case study was conducted using a calculation method to find the Overall Coefficient (U) and Dirt Factor (Rd) which will then be calculated for Pressure Drop and Heat Efficiency. After obtaining these observational data, it can be concluded whether the heat exchanger is still feasible to operate or not. Everything that is done from problem formulation to decision making is modeled in the form of a flow chart which is expected to be able to explain the steps to be taken.

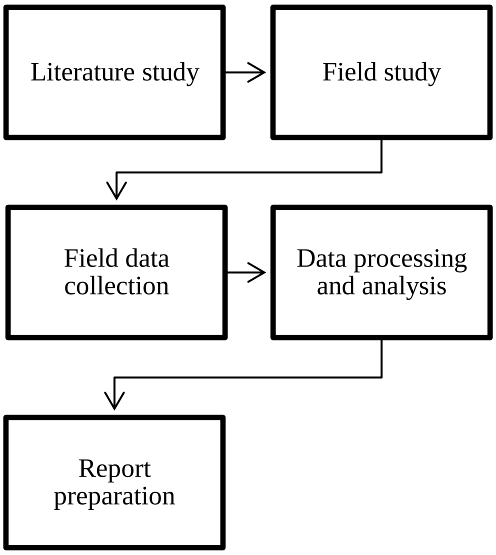

Figure 1. Research block diagram

3. Results and Discussion

Based on the results of data collection, in order to know the performance evaluation of the Heat exchanger 001, the following data were obtained:

1. Uc = 7,4301 Btu/ft^2.hr.^oF
2. Ud = 7,2517 Btu/ft^2.hr.^oF
3. Rd = 0,0033 ft^2.hr.^oF/Btu
4. Pressure Drop Shell = 0,0448 Psi
5. Pressure Drop Tube = 0,0035 Psi
6. Heat Efficiency = 82,3840%

3.1 Overall Coefficient (U)

Calculation step of clean overall coefficient (Uc), calculating the outer heat transfer coefficient with the equation (1) : (Kern,1965)

$$ho = \frac{ho}{\emptyset_s} + \emptyset_s \quad (1)$$

Where ho is the heat transfer coefficient on the outside and $\emptyset_s$ is correction factor of shell. Meanwhile, to calculate the internal heat transfer coefficient, it can be shown by equation (2) :

$$hio = \frac{hio}{\emptyset_t} + \emptyset_t \quad (2)$$

Which is hio the internal heat transfer coefficient and $\emptyset_t$ is correction factor of tube. After equations (1) & (2) are performed, the value of the clean overall coefficient is obtained which is indicated by equation (3):

$$Uc = \frac{hio \ x \ ho}{hio + ho} \tag{3}$$

The calculation step of design overall coefficient (Ud). Calculating the heat in the tube can be shown by equation (4) while to get the value of ΔT_{LMTD} it can be shown by equation (5) :

$$Q_t = W \ x \ Cp \ x \ \Delta T \tag{4}$$

$$\Delta T_{LMTD} = LMTD \ X \ F_T \tag{5}$$

Where Q_t is the heat in the tube, W is the flowrate of crude oil, Cp is the specific heat of crude oil, ΔT is the difference between the exit temperature and the inlet temperature of crude oil, ΔT_{LMTD} adalah Logarithmic Mean Temperature Difference, dan F_T is the correction factor, obtained from fig. 19 Kern. After calculating the equations (4) and (5), the overall design coefficient which is explained in equation (6) :

$$Ud = \frac{Q_t}{Nt \ x \ a'' \ x \ L \ x \ \Delta T_{LMTD}} \tag{6}$$

Nt is the number of tubes, a” is the flow area, obtained from table 10 Kern and L is the length of the tube.

3.2 Dirt Factor (Rd)

Calculation step dirt factor is to use equations (3) & (6) to get the dirt factor (Rd) value which is stated in equation (7) :

$$Rd = \frac{Uc - Ud}{Uc \ x \ Ud} \tag{7}$$

To evaluate the performance of the heat exchanger, the parameter used is fouling factor/dirt factor (Rd). Fouling which can be defined as the accumulation of unwanted solids on the surface of a manufacturing equipment because it can impair the surface's ability to transfer heat at a desired temperature difference. Fouling in the heat exchanger is one of the important problems in heat transfer equipment.

The higher the dirt factor (Rd), the more solids accumulate and cause the performance of the heat exchanger to decrease, and vice versa. The fouling factor itself is influenced by the value of the clean overall coefficient (Uc) and overall design coefficient (Ud). In the calculation of the operating data of the Heat Exchanger-001, the Uc value is 7.4301 Btu/ft^2.hr.^{o}F and Ud values of 7.2517 Btu/ft^2.hr.^{o}F. The Ud value obtained can also be used as a reference to see the condition of the heat exchanger, where the more dirt accumulates on the surface of the heat exchanger, the smaller the Ud value obtained will be. The overall heat coefficient indicates whether or not heat is easy to move from a high-temperature fluid to a lower-temperature fluid. In addition, the overall heat coefficient also expresses the overall heat flow as a combination of conduction and convection processes. The dirt factor (Rd) value is 0.0033 ft^2.hr.^{o}F/Btu which is when a comparison is made between the calculated Rd value and the constant Rd value with a magnitude of 0.003 ft^2.hr.^{o}F/Btu, it can be concluded that the Heat Exchanger-001 currently has very little accumulation of impurities both from crude oil and from diesel fuel and may not affect the performance of the HE-001 because it still meets the fixed Rd value.

3.3 Pressure Drop

Steps for calculating Pressure Drop Shell. By calculating the Reynolds number shell expressed in equation (8) :

$$Re_s = \frac{D_e x G_s}{\mu_s} \quad (8)$$

Where Re_s is the reynold number of shell, D_e is the equivalent diameter, μ_s is the viscosity of the fluid in the shell. Next, look for the cross value in equation (9) :

$$N + 1 = \frac{12L}{B} \quad (9)$$

N+1 is the cross value, L is the length of the shell and B is the distance between the baffles on the shell. Then we can find the value of the Pressure Drop with the equation (10) :

$$\Delta P_s = \frac{f \ x \ G_s^2 \ x \ D_s x \ (N+1)}{5{,}225 \ x \ 10^{10} \ x \ D_e \ x \ Sg \ x \ \emptyset_s} \quad (10)$$

ΔP_s is the shell pressure drop, f is the friction factor, obtained from fig. 29 Kern, G_s is the mass velocity of shell, D_s is the diameter of shell, Sg is the specific gravity

Steps for calculating Pressure Drop Tube. Calculate the reynold number of tube stated in equation (11) :

$$Re_t = \frac{D \ x \ G_t}{\mu_t} \quad (11)$$

Where Re_t is the reynold number of tube, D is the tube inner diameter, μ_t is the viscosity of the fluid in the tube and G_t is the mass velocity of tube. Furthermore, the Pressure Drop in equation (12) :

$$\Delta P_t = \frac{f \ x \ G_t^2 \ x \ L \ x \ n}{5{,}225 \ x \ 10^{10} \ x \ D \ x \ Sg \ x \ \emptyset_t} \quad (12)$$

With the information ΔP_t is the pressure drop of tube, G_t is the mass velocity tube, L is the length of tube, n is the number of passes, $\emptyset_t$ is the correction factor of tube

3.4 Heat Eficiency

Heat Efficiency calculation steps. First, calculate the incoming heat with equation (13) :

$$Q_{in} = Q_s - Q_t \quad (13)$$

Where Q_{in} is the heat in, Q_s is the heat in the shell, Q_t is the heat in the tube. Followed by calculating the heat lost and heat transferred in equation (14) & (15) :

$$Q_{losses} = \frac{losses}{100} x Q_{in} \quad (14)$$

$$Q_{transferred} = Q_{in} - Q_{losses} \quad (15)$$

Where Q_{losses} are heat loss, losses = heat lost (%), Q_{in} = heat in, $Q_{transferred}$ = heat transferred, η is efficiency (%). Then the calculation of Heat Efficiency is expressed in the equation:

$$\eta = \frac{Q_{transferred}}{Q_{masuk}} x100 \quad (17)$$

Other parameters used in evaluating the performance of the heat-exchanger-001 are Pressure drop and Heat Efficiency. Pressure drop is a pressure drop that occurs in operating equipment. Meanwhile heat efficiency is the ratio of the amount of heat that moves from a high temperature fluid to a lower temperature fluid in a certain time unit which can show the performance of a heat exchanger.

Calculation of actual, the pressure drop on the shell is 0.0448 Psi, while the tube is 0.0035 Psi. The pressure drop value is still below the allowable standard value of 10 Psi. This states that the Heat Exchanger-001 is still feasible to operate because it does not exceed the permissible limit [3]. Based on the relationship with the dirt factor obtained and its causes, the pressure drop that occurs on the HE-001 is caused by the accumulation of impurities on the surface of the tube and shell. This causes friction between the fluid flow and the surface of the tube and shell which can lead to a decrease in the pressure of the Heat Exchanger-001.

Based on the calculation results, the heat efficiency is 82.3840%, where the heat entering the heat exchanger from the diesel fluid in the shell 656,821.2486 Btu/hr, the incoming heat from the crude oil 501.115.198 Btu/hr, so the accumulation heat entering the Heat Exchanger-001 is 115,705.93 Btu/hr. The amount of heat transferred between the hot fluid to the fluid is 95.323.1233 Btu/hr. The amount of heat efficiency obtained is influenced by several factors, including the thickness of the tube, specific heat the fluid, and the presence or absence of accumulated dirt on the inner and outer walls of the tube. This accumulated dirt is indicated by the dirt factor (Rd) obtained in the previous calculation. The larger the dirt that accumulates on the tube, both inside and outside, the lower the heat efficiency obtained, and vice versa. [3]

4. Conclusion

Based on the calculation results, the value of the parameters used to determine the work efficiency of the Heat Exchanger-001, namely the dirt factor (Rd) of 0.0033 ft^2.hr/Btu. Pressure drop is 0.0448 Psi on the shell and 0.0035 Psi on the tube, with a maximum permitted of 10 Psi. And the value of heat efficiency is 82.3840%. According to the results of these parameters, it can be concluded that Heat Exchanger-001 is still feasible to use. However, it is still necessary to pay attention to the maintenance and frequency of periodic cleaning of the heat exchanger. This aims to maintain optimal performance of the heat exchanger.

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