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RESEARCH ARTICLE

Performance Evaluation of Shell and Tube Heat Exchanger With Capacity of 100,000 Btu/Day in Cilacap

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Kata Kunci:
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Abstrak

Penukar panas (HE) adalah alat yang memiliki peran penting dalam industri pengolahan minyak dan gas. Khususnya di unit Fuel Oil Complex I (FOC I) yang bertugas memisahkan minyak mentah menjadi fraksi-fraksi seperti LPG, naphtha ringan, naphtha berat, kerosin, Light Gas Oil (LGO), Heavy Gas Oil (HGO), dan residu panjang. Penggunaan penukar panas secara terus-menerus akan menyebabkan pengotoran (fouling) seiring waktu. Industri pengolahan minyak dan gas Cilacap menggunakan jenis penukar panas tipe shell and tube karena memiliki keunggulan dari segi biaya, fabrikasi, dan efektivitas kerja. Hasil evaluasi perbandingan faktor pengotor (Rd) dan nilai penurunan tekanan pada data desain dan data aktual pada 1 Juni - 30 Juli 2024 menunjukkan bahwa nilai faktor pengotor aktual (Rd) lebih besar dibandingkan nilai faktor pengotor desain (Rd). Sedangkan nilai penurunan tekanan ΔP aktual pada sisi shell dan sisi tube lebih kecil dibandingkan nilai penurunan tekanan desain karena laju aliran aktual jauh lebih kecil dari laju aliran data desain. Rekomendasi yang diberikan adalah evaluasi dan pembersihan secara berkala terhadap kotoran, lumpur, dan kerak yang terakumulasi di dinding shell dan tube untuk menjaga kinerja penukar panas..

Key Word:
Penukar Panas, Shell and Tube, Faktor Pengotor, Penurunan Tekanan.

Abstract

A heat exchanger (HE) is a heat exchanger that has a vital role in the oil and gas processing industry. Especially in the Fuel Oil Complex I (FOC I) unit, which is tasked with separating crude petroleum into fractions such as LPG, light naphtha, heavy naphtha, kerosene, Light Gas Oil (LGO), Heavy Gas Oil (HGO) and long residue. The continuous use of heat exchang-ers will cause fouling over time. The Cilacap oil and gas processing industry uses a shell and tube type heat exchanger because it has cost, fabrication, and work advantages. The evalua-tion results of the comparison of the fouling factor (Rd) and pressure drop values on the de-sign data and actual data on 1 June - 30 July 2024 show that the actual fouling factor (Rd) value is greater than the design fouling factor (Rd) value. While the actual ΔP pressure drop shell side and tube side values are smaller than the design pressure drop values because the actual flow rate is much smaller than the design data flow rate. The recommendation is peri-odic evaluation and cleaning of accumulated dirt, mud, and scale found on the shell and tube walls to maintain heat exchanger performance.

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INTRODUCTION

The heat transfer process is one of the most critical processes in the oil and gas processing industry, and it uses a heat exchanger (HE). Its function is to convert energy into heat when interacting with liquids by regulating the high and low temperatures so that the production process continues to run as needed, directly or indirectly. The Cilacap oil and gas processing industry uses a shell and tube type heat exchanger because it has cost, fabrication, and work advantages. Among other things, it has a larger heat transfer surface area ratio, is produced in various sizes and flows more easily, can operate at high Pressure and high efficiency, has a large surface area at small volume sizes, and is easier to maintain because the construction between one another is not in one unit.

Energy exchange in fluids in heat exchangers can occur between fluids in the same phase or fluids in different phases. The use of heat exchangers to maximize energy sources for heating and cooling plays an important role in the process of achieving the desired feed or product temperature conditions. The use of heat exchangers continuously and increasingly will affect its performance because it will cause fouling. The impact of thermal resistance and heat transfer rate will decrease from the original, which shows the magnitude of the resistance due to dirt, thus affecting the performance of the heat exchanger.

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Heat exchangers have a very important role in production in the Fuel Oil Complex I (FOC I) unit in charge of separating crude petroleum into fractions such as LPG, light naphtha, heavy naphtha, kerosene, Light Gas Oil (LGO), Heavy Gas Oil (HGO) and long residue. If HE's performance cannot meet the desired standards, it will significantly impact the company. Therefore, it is essential to evaluate HE performance by comparing Dirt Factor/Fouling factor (Rd) design data and actual data so that the production process continues to run properly. The results of this evaluation are the basis for carrying out the cleaning process if the HE performance has decreased.

The fouling factor affects the heat transfer process because it can inhibit the movement of heat due to deposits. If the calculated fouling factor value is greater than the design fouling factor value, the heat transfer in the device does not meet the performance of the process and must immediately carry out the cleaning process. Evaluation of the fouling factor to determine the presence of dirt in the tool and cleaning time. The greater the fouling factor value, the lower the heat transfer efficiency and the higher the pressure drop value. This can cause a decrease in the performance of the heat exchanger. The determination of the fouling factor is based on the price of the overall heat transfer coefficient for clean and dirty conditions in the use of heat exchangers.

Given the important role of heat exchangers in the oil and gas processing process based on the explanation above. The author conducted this research to analyze the heat exchanger heat transfer to determine its performance using the Kern method regarding LMTD value and get the final value Rd. The relevant industry parties can maintain regular heat exchangers if the fouling factor exceeds the permit limit. Emphasis on the thermal efficiency of the heat exchanger as an economic measure by utilizing energy efficiently and wisely to minimize operating costs.

METHOD

The research process and stages are as follows:

Data Collection

The data required to evaluate the heat exchanger includes design data, specification data, and actual operating data such as inlet outlet temperature, inlet flow rate and fluid composition in the inlet.

Calculations

The calculation stages in evaluating heat exchanger performance are as follows [9]:

1. Heat Balance Calculation
   a. Heat Balance Cold Fluid

   $$Qc = m_c \times Cp_c \times (t_2 - t_1) \quad \ldots\ldots (1)$$

   b. Heat Balance *Hot Fluid*

   $$Qc = m_h \times Cp_h \times (T_2 - T_1) \quad \ldots\ldots (2)$$

   Description:
   Qc = heat taken in, Btu/hr
   Mc = Massa *cold* fluid, lb/hr
   Cp_c = heat capacity *cold fluid*, Btu/lb˚F
   Cp_h = heat capacity *hot fluid*, Btu/lb˚F
   t_1 = inlet temperature *cold fluid*, ˚F
   t_2 = outlet temperature *cold fluid*, ˚F
   T_1 = inlet temperature *hot fluid*, ˚F
   T_2 = outlet temperature *hot fluid*, ˚F
2. *Log Mean Temperature Difference* (LMTD) Calculation

   $$\Delta T_{LMTD} = \frac{\Delta(T_1 - t_2) - \Delta(T_2 - t_1)}{In\left(\frac{\Delta(T_1 - t_2)}{\Delta(T_2 - t_1)}\right)} \quad \ldots\ldots (3)$$

   ΔT_{LMTD} can be corrected with the following equation:

   $$\Delta t = \Delta T_{LMTD} \times Ft \quad \ldots\ldots (4)$$

   Description:
   Δt_1 = T_{in} hot fluid - T_{out} hot fluid
   Δt_2 = T_{out} hot fluid – T_{in} hot fluid
   Ft = Correction Factor
3. *Temperature Caloric* (Tc dan tc) Calculation

   $$T_c = \frac{T_1 + T_2}{2} \quad \ldots\ldots (5)$$

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$t_c = \frac{t_1+t_2}{2}$ ..... (6)

4. *Flow* Area Calculation

a. Flow Area *Shell*

$a_s = \frac{ID_s \times C \times B}{144 \times P_t}$ ..... (7)

Description:
a_s= *Flow* area *shell*, ft^2
ID_S = *Shell inside* diameter, ft
C= *Tube* clearance, inch
B= buffle spacing, inch
P_t = *Pitch Tube*, inch

b. Flow Area *Tube*

$a_t = \frac{N_t \times a\prime t}{144 \times n}$ ..... (7)

Description:
a_t= *Flow Are Tube side*, ft2
N_t = Tube Quantity
a'_t = *Flow Area Per Tube*, in2
n = Number of pass

5. *Mass Velocity* Calculation

a. Mass Velocity Shell

$G_s = \frac{W}{a_s}$ ..... (8)

Description:
a_s= *flow rate area shell*, ft^2
W = *Flow rate hot fluid*, lb/hr
G_s = *Mass Velocity* pada *shell*, lb/ft^2

b. Mass Velocity Tube

$G_t = \frac{W}{a_t}$ ..... (9)

Description:
a_t = *Flow rate area* shell, ft^2
W = *Flow rate hot fluid*, lb/hr
G_t = *Mass Velocity* pada *shell*, lb/ft^2

6. *Reynold Number Calculation*

The flow type is determined using the Reynold number. The Calculation of the Reynold number on the shell uses the viscosity at the time of the cold fluid calorific temperature, and the Calculation of the Tube Reynold number uses the viscosity at the time of the hot fluid calorific temperature. The equivalent diameter value in the shell is obtained from the Kern graph, while the diameter value in the Tube is obtained from the Kern table based on the outside diameter of the Tube and BWG found in the heat exchanger design data [10]

a. Reynold's Number of Shell

$Re_s = \frac{D_e G_s}{\mu_h}$ ..... (10)

$D_e = \frac{4 \times (^1/_2 P_T \times 0{,}86\, P_T - \frac{^1/_2 \pi d^2 o}{4}}{^1/_2 \pi d_o}$ ..... (11)

Description:
Re_s = Reynold's Number of Shell
D_e = *Equivalent Diameter*, ft
μ_h = *Viscosity cold fluid*, centipoise x 2,42 = lb/(ft.hr)
G_s = *Mass Velocity* pada *shell*, lb/(ft^2.F)
P_T = *Tube Pitch*, in
d_o = *Outside Diameter of Tube*, ft

b. Reynold's Number of *Tube*

$Re_t = \frac{DG_t}{\mu_c}$ ..... (12)

Description:
Ret = Reynold's Number of Tube

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D = Inside *Diameter of Tube*, ft
μc = *Viscosity cold fluid*, centipoise x 2,42 = lb(ft.hr)
Gt = *Mass Velocity* pada *tube*, lb/(ft^2.˚F)

7. *Heat Transfer Factor* (jH) Calculation
After obtaining the Reynold number, determine jH by reading the graph on h_o and h_i calculations.

a. *Heat Transfer Coefficient* pada *Shell*

$$h_o = jH \frac{k_h}{D_e}\left(\frac{c_h \mu_h}{k_h}\right)^{1/3} \emptyset_s \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

b. *Heat Transfer Coefficient* pada *Tube*

$$h_i = jH \frac{k_c}{D_e}\left(\frac{c_c \mu_c}{k_c}\right)^{1/3} \emptyset_c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

$$h_{io} = h_i \times \frac{ID}{OD} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

Description:
h_o = *Heat Transfer Coefficient for outside fluid*, Btu/(hr.ft^2.F)
h_i= *Heat Transfer Coefficient for inside fluid*, Btu/(hr.ft^2.F)
h_{io} = *Heat Transfer Coefficient for inside fluid*
jH = *Factor for Heat Transfer*, dimensionless
μ_h = *Viscosity Hot Fluid*, centipoise x 2,42= lb/(ft.hr)
k_h = *Thermal Conductivity hot fluid*, Btu/(hr.ft^2.F/ft)
k_c = *Thermal Conductivity cold fluid*, Btu/(hr.ft^2.F/ft)
C_h = *Specific heat of hot fluid*, Btu/(lb.˚F/ft)
C_c = *Specific heat of cold fluid*, Btu/(lb.˚F/ft)
De = *Equivalent Diameter*, ft
Φs = *viscosity ratio*, (μh/ μair)^{0,14}
ID = *Inside diameter of Tube*, in
OD = *Outside diameter of tube*, in

8. Determining *Tube Wall Temperature*

$$t_w = t_c + \frac{h_o}{h_{io}+h_o}(T_c - t_c) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

Description:
t_w = Tube outer wall temperature, ˚F
t_c = *Caloric Temperature* of *Cold Fluid*, ˚F
T_c = *Caloric Temperature* of *Hot Fluid*, ˚F
h_{io} = *Heat Transfer Coefficient for inside fluid when referred* to the *tube outside* diameter, Btu/(hr.ft^2. ˚F)

9. Calculation Of Corrected Heat Transfer Coefficient

$$h_o = \left(\frac{h_o}{\emptyset_a}\right) \times \emptyset_{a_{tw}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

$$h_{io} = \left(\frac{h_{io}}{\emptyset_p}\right) \times \emptyset_{p_{tw}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

Description:
h_{io} = *Heat Transfer Coefficient for inside fluid when referred to the tube outside diameter*, Btu/(hr,ft2.˚F)
ho = *Heat Transfer Coefficient for outside fluid*, Btu/(hr.ft2.˚F)
Øa$_{tw}$ = *Viscosity ratio pada saat tw*, (μc/μair)^{0,14}
Øp$_{tw}$ = *Viscosity ratio pada saat tw*, (μh/μair)^{0,14}

10. Net Heat Transfer Coefficient Calculation (U_c)

$$U_c = \frac{h_o \times h_{io}}{h_o + h_{io}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

Description:
U_c = *Clean Overall Coefficient*, Btu/(hr.ft^2.˚F)
h_{io} = *Heat Transfer Coefficient for inside fluid* when referred to the *tube outside* dia meter, Btu/(hr,ft^2.˚F)
h_o = *Heat Transfer Coefficient for outside fluid*, Btu/(hr.ft^2.˚F)

11. Dirt Heat Transfer Coefficient Calculation (U_d)

$$Q = U_d A(\Delta T_{LMTD}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

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Description:
Q = *Heat Flow*, Btu/hr
A = *Heat Transfer Surface*, ft2
ΔT_{LMTD} = *Log Mean Temperature Difference*, ˚F
U_d = *Dirt Overall Coefficient*, Btu/(hr.ft2.˚F)

12. *Dirt Factor* Calculation (Rd)

$$R_d = \frac{U_c - U_d}{U_c \times U_d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

Description:
R_d = *Dirt Factor*, (hr.ft2.˚F)/Btu
U_c = *Clean Overall Coefficient*, Btu/(hr.ft^2.˚F)
U_d = *Design Overall Coefficient*, Btu/(hr.ft^2.˚F)

13. *Pressure drop* Calculation

a. *Pressure drop* on *Shell*

$$\Delta P_s = \frac{f G_s^2 D_e (N+1)}{5{,}22 \times 10^{10} D_e s \emptyset_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

b. *Pressure drop* on *Tube*

$$\Delta P_t = \frac{f G_s^2 D L_n}{5{,}22 \times 10^{10} D_e s \emptyset_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (23)$$

$$\Delta P_r = \frac{4n}{s} \times \frac{V^s}{g'} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

Total *tube pressure drop*:

$$\Delta P_T = \Delta P_t + \Delta P_r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

Description:
ΔP_s = *Pressure Drop* pada *Shell*, psi
ΔPt = *Pressure Drop* pada *tube*, psi
ΔPr = *Pressure Drop Return* pada *Tube*, psi
ΔP_T = *Pressure Drop Total* pada *Tube*, psi
De = *Equivalent Diameter*, ft
f = *Friction Factor*
(N+1) = *Number of crosses*, L/B
$\emptyset_h$ = *Viscosity ratio hot fluid*, $(\mu c/\mu air)^{0,14}$
D = *Inside Diameter of Tube*, ft
L = *Length of tube*, L/B
N = *Viscosity ratio cold fluid*, $(\mu c/\mu air)^{0,14}$
n = *Number of passes*
g’ = Gravitational acceleration, ft/sec2
V = Velocity, fps
s = *Spesific Gravity*

RESULT AND DISCUSSION

Tables 1 and 2 below show the appliance specification data and HE operating design used:

Table 1. HE Equipment Specification Data

HE	*Shell*		*Tube*		Units
	Notation	Dimention	Notation	Dimention	
Outside Diameter	OD	52,204	OD	0,75	*inch*
Inside Diameter	ID	51,18	ID		*inch*
Number of Baffle	N	11	N		
Number of *Pass*	N	4	N	2	
BWG		14		14	
Tube spacing	C’		C’	1	*Inch*
Tube Length	L		L	20	*Ft*
Tube Quantity	Nt		Nt	1402	pcs
Pitch				1	*Inch*
Spacing between baffles	B	25,59			*Inch*
Tube Arrangement			*Diamond square pitch*		

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Table 2. Design HE Data

HE	*Shell*	*Tube*	Units
Fluid	*Naphta*	*Heavy Diesel Oil*	
Flow Rate	1.773.025,10	1.225.286,16	*Lb/hr*
inlet temperature	348,8	575,6	˚F
outlet temperature	745,21	455	˚F
Temperature Difference	360,41	120,6	˚F

Table 1. Actual Operation Data (1 June - 30 July 2024)

HE	*Shell*		*Tube*		Units
	Notation	Dimention	Notation	Dimention	
Fluida	*Naphta*		*Heavy Diesel Oil*		
Flow Rate	Ws	423.263,23	Wt	298.849,79	*Lb/hr*
inlet temperature	t1	376,74	T1	618,8	˚ F
outlet temperature	t2	396,23	T2	505,67	˚F
Temperature Difference	Δt	19,49	ΔT	113,13	˚F

Research Results

a) Fouling Factor

The fouling factor is a parameter of the amount of resistance of a heat exchanger device from its impurities, which shows the level of impurity factor in the heat exchanger due to a layer of unwanted material or compound impurities. The materials or compounds are crystals, sediments, biological compounds, chemical reaction products or corrosion. The accumulation of impurities can cause a decrease in heat transfer efficiency, a decrease in the value of the overall heat transfer coefficient (U) and heat on the actual surface area so that it does not get the required heat. [6] In addition, it causes the value of Rd (fouling factor) by friction between the heat exchanger pipe wall and the fluid. The fouling and corrosion factor is crucial in heat exchanger operation because it will have a very large effect on economic factors, so constantly monitor the evaluation of the heat exchanger so that it does not have a very large effect on operational costs and effectiveness.

Table 4. *Fouling Factor (Rd) Number*

Data *Design*		Data Actual	
Shell Side (BTU/hr.ft^2)	*Tube Side* (BTU/hr.ft^2)	*Shell Side* (BTU/hr.ft^2)	*Tube Side* (BTU/hr.ft^2)
0,0004	0,0011	0,15	0,018

The evaluation results of Table 4 show the comparison of the fouling factor (Rd) values in the design data and actual data on 1 June 2024 - 30 July 2024 on the shell side and tube side, respectively of 0.0004 BTU/hr.ft2, 0.0011 BTU/hr.ft2, 0.1477 BTU/hr.ft2 and 0.0179 BTU/hr.ft2. This shows that the actual fouling factor (Rd) value is greater than the design fouling factor (Rd) value. This means that the greater the fouling factor value, the higher the amount of impurities (deposits), so the heat transfer process does not run optimally. The heat absorbed by the cold fluid is not optimal because the resistance (friction) between the fluid and the heat exchanger pipe wall to the heat transfer process is getting bigger, so the heat transfer coefficient becomes small. The recommendation of the calculation R_d evaluation result is greater than the design R_d, which is to do the cleaning.

R_d values below the minimum limit will cause additional heat or energy transfer resistance. The amount of Rd is also caused by the scale on the Tube or shell that forms moss, thus inhibiting heat transfer. It can be seen that the performance affects the product produced, where the increase in R_d value indicates that there is an accumulation of deposits, scale, and fouling on the shell side and tube side, so cleaning is needed. In addition, fouling can occur due to corrosion caused by rust on the metal. The higher the fouling factor (R_d) value, the less efficient the heat exchanger.

Researchers stated that there are two methods of cleaning heat exchangers: mechanical cleaning, chemical cleaning and a combination of both. The mechanical cleaning method is by disassembling the heat exchanger parts to clean the dirty parts. The chemical cleaning method is by flowing a chemical solvent into the heat exchanger wall and bringing it out. The process of fouling layer formation is a very complex and different phenomenon. Based on the process of forming deposits or dirt, fouling is divided into five types: precipitation fouling, particulate fouling, biology, corrosion, chemical reactions, and freezing fouling. Measures to prevent fouling include using corrosion-resistant construction materials, filtering, injecting antifoulants into the fluid and placing nozzles (shell and tube side) on the lowest or highest surface of the heat exchanger to avoid gas pockets or stationary fluid volume pockets.

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Fouling cannot be prevented, and the shell and tube type has an easy cleaning construction. The fouling factor depends on the value of the Clean Overall Heat Transfer Coefficient (U_c) and Dirt Overall Heat Transfer Coefficient (U_d). He has a high level of durability and can be reused when the U_d value is smaller than Uc, or the Uc value is higher than the Ud value, which represents a higher surface level. Heat exchanger cleaning during Turn Around (TA) serves to restore its function so that the performance of the heat exchanger is optimized

b) *Pressure Drop*

The pressure drop from one area of the system to an area with lower Pressure is known as pressure drop (ΔP), which occurs as a result of fluid accumulation in the pipe due to resistance. Pressure drop on the shell and Tube is not allowed to exceed the limit permitted based on design data, so to find out how much fluid is able to maintain the Pressure that has been owned as long as the fluid flows from inside the shell side and tube side of the heat exchanger tool, it is compared with the pressure drop design on the heat exchanger.

The results of the HE design data calculation show a pressure drop on the shell of 0.996 psi and a maximum of 1.42 psi, while on the Tube, 4.836 Psi and a maximum of 19.91 psi. The actual HE data calculation taken on 1 June 2024- 30 July 2024 shows the ΔP value on the shell side and tube side of 0.71 Psi and 2.87 Psi. It can be compared that the actual shell side and tube side pressure drop is smaller than the design pressure drop value even though the actual shell side flow rate is smaller than the design shell side flow rate, but the pressure drop value is still below the existing limit. This is due to the ability of the flowing fluid to maintain Pressure so that the pressure drop is not too significant. In addition, one of the factors that can affect pressure drop is flow rate. It can be seen in the operating data that the actual flow rate is much smaller than the design data. The design flow rate on the shell side and tube side is 1,773,025.1 lb/hr and 1,225,286.16 lb/hr. At the same time, the actual flow rate on the shell side and tube side is only 423,263.23 lb/hr and 298,849.79 lb/hr.

Pressure drop can also affect the efficiency of the heat exchanger. The decrease in heat transfer efficiency indicates heat loss to the environment so that the heat energy of the hot fluid (HDO) is lower than the amount of heat it has. In addition, the decrease in efficiency in heat exchangers is also influenced by pressure drop, heat transfer coefficient, fluid mass flow rate, and the level of dirtiness in the heat exchanger. HE efficiency can be increased by increasing the cold fluid flow rate.

CONCLUSION

The author's conclusion after evaluating and calculating the heat exchanger: a) Dirt factor/fouling factor (Rd) on Heat Exchanger CDU II obtained a value based on the Calculation of 0.1477 BTU/hr.ft2.°F on the shell and 0.0179 BTU/hr.ft2.°F for the Tube. Meanwhile, the Rd design on the shell and Tube is 0.0004 BTU/hr.ft2.°F and 0.0011 BTU/hr.ft2.°F. It shows that the heat exchanger needs cleaning so that its performance can be even better; b) Pressure drop (ΔP) on the Heat exchanger obtained a value based on calculations of 0.71 Psi in the Shell section, while in the Tube section, it is 2.87 Psi. At the same time, the ΔP value on the shell and tube design is 0.996 Psi and 4.836 Psi. The actual shell side and tube side pressure drop is smaller than the design pressure drop value. Even though the actual shell side flow rate is smaller than the shell side design flow rate, the pressure drop value is still below the existing limit. This is due to the ability of the flowing fluid to maintain Pressure so that the pressure drop is not too significant. In addition, flow rate is another factor that can affect pressure drop. It can be seen in the operating data that the actual flow rate is much smaller than the design data.

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