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STUDI OF SREAM DISTRIBUTION AND BOILER PERFORMANCE INDOMARINE AT PT. EASTERN PEARL FLOUR MILLS

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ABSTRACT

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The process of making pellets at PT. Estren Pear flour Millss require hot steam generated from the Indomarine boiler. This study aims to determine the performance of Boier Indomrine. The research method used is to collect measured data on instruments and stored in the control documents of PT. Eastern Pearl Flour Mills. The results of the calculation show that the heat energy loss in the distribution pipe installation is 32.5 kW, while the available fuel energy from the combustion process is 2334311 kJ / hour. mass balance of the working fluid that occurs is the mass rate of feed water used is 1126.35 kg / hour, the mass rate of steam produced is 934.35 kg / hour. While the rest came out through the blow down process of 192 kg / hour.

Keywords: Boiler, Efficiency, Heat Loss, Energy Balance

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1. Preliminary

PT. Eastern Pearl Flour Mills is one of the wheat flour and pellet industries located in the city of Makassar. In the production process, besides producing wheat flour, it also produces pellets. In the process of making this pellet, hot steam is needed which is produced from a steam boiler or boiler. A boiler or steam boiler is a means of producing hot steam which is produced from the combustion process. The hot steam produced in the combustion process has a certain temperature and pressure that can be used for a production process. The hot steam produced after the combustion process will be flowed through the pipe and used for the pellet-making process. The trip of hot steam from the hot steam outlet until it is used for the pellet-making process will occur a heat transfer process from the hot steam temperature to the environment, so that there will be a difference in the temperature of hot steam from the hot steam outlet to the pellet-making process and also the steam that returns to the system. The heat transfer process that occurs from the pipe connecting the hot steam outlet to the pellet production process to the environment is very detrimental, because the temperature of the hot steam in the pipe will decrease.

Steam distribution connects steam production and steam users and is tasked with maintaining steam quality by preventing heat loss so that steam condensation can be reduced. The vapor pressure gradually drops due to flow resistance and condensation. Reducing the temperature of the hot steam will affect the length and quality of the pellet making process because the temperature of the hot steam has been reduced due to the trip from the hot steam outlet to the pellet machine system. Energy saving is a great opportunity to be done through improving the performance of the steam distribution system.

2. Study of literature

2.1 Basic Theory of Heat Transfer

Heat Transfer Heat transfer is the study of energy transfer in a material due to the difference (gradient) temperature. This heat transfer always occurs from a high temperature system to another system with a lower temperature and stops after the two systems reach the same temperature, the temperature difference is the main condition for heat transfer, if both systems have the same temperature there will be no heat transfer at Both systems. The amount of heat flow is expressed by the notation Q in units of energy, namely joules (j).

While the heat flow rate is the energy flow per unit time (hours or seconds) expressed by the notation Q (Q dot) generally in watts (W). In addition there is also a rate of heat flow per unit area (q dot) which is often referred to as heat flux or specific heat flow. The values of Q and q are vectors whose direction coincides with the direction of heat distribution. The science of heat transfer not only tries to explain how heat energy passes from one object to another, but can also predict the rate of heat transfer that occurs under certain conditions. There are three types of heat transfer, namely conduction,

2.2 Heat Transfer

The heat generated due to the combustion of fuel and air, in the form of fire (which is burning) is transferred to water, steam or air, through a heated area in an installation by:

1. Transfer of conduction heat

Conduction heat transfer is the transfer of heat from one part of the object to another part of the same object or from one solid object to another due to physical contact (attached physical contact), without the transfer of molecules from the object itself. . An example is the heat that transfers from the outer surface of the pipe to the inner surface of the pipe in the boiler.

From the 1822 Fourier Law found by Jean Baptiste Joseph Fourier (1768-1830), the Conduction Equation is obtained:

$$q_{x=} \frac{dT}{dx} / kA \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$q_{x} = k\,A\,\frac{dT}{dx} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

qx: Heat transfer rate in the x direction (Watts or cal / s, or Btu / hr)
dT: Difference in temperature (K, oC or oF)
dx: Heat transfer distance (m, cm or ft)
A: Cross-sectional area (m2, cm2, or ft2)
k: heat conductivity (Watt / mk, cal / dt.oC.cm, or Btu / hr.oF.ft)

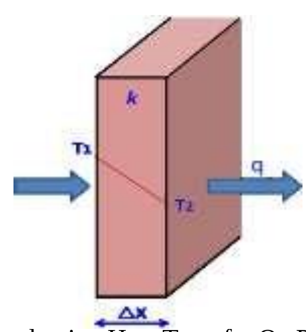

Figure 1. Conduction Heat Transfer On Plate

2. Convection heat transfer

Convection heat transfer is a heat transfer process carried out by the molecules of a fluid which takes place through the movement of fluids (liquid or gas). So the fluid molecules are intermediaries that carry heat from one place to another. An example is the process of transferring heat from waste gas to the economizer element in the boiler.

Convection heat transfer is divided into two, namely:

a. Forced convection is when the motion of the molecules is a result of mechanical forces (due to being pumped or blown with a blower).
b. Free convection is when the motion of molecules = molecules hovering because of the temperature difference in the fluid itself.

The overall heat transfer from the flow agent in the pipe to the flow agent outside the pipe is

$$Q = \frac{T_g - T_{wt}}{\frac{1}{h_i A_i} + \frac{\ln(\frac{r_0}{r_i})}{2\pi k l} + \frac{1}{h_o . A_0}} \dots\dots\dots\dots\dots\dots\dots \dots \dots\dots$$
3)

3. Radiation heat transfer

Radiation is the process of transferring heat across space through the emission of electromagnetic waves at the speed of light from objects of higher temperature to objects of lower temperature. Radiation heat transfer in the combustion chamber radiation exchanges between the gas and a surface. An example is the heat transfer process that occurs in the boiler combustion chamber when heat from the gas is emitted to the wall of the combustion chamber (wall tube).

According to JP Holman, the heat transfer rate of gas radiation in the combustion chamber can be calculated by:

$$\frac{q_{radiasi}}{A_R} = \epsilon_g (T_g) \sigma T^4 - \alpha_g (T_g) \sigma T^4 \dots\dots (3)$$

Information :
q = Radiation heat transfer rate (kJ / h)
ϵ= Gas emissions
c = Stefan-boltzmann constant and assumed = [5.669x10-8 W / m2K]
AT = Area heated (m2)
Tg = Temperature of combustion chamber gas (K)
Tw = temperature of the combustion chamber wall (K)

4. Boiler as a steam generator

A boiler is a closed vessel where the heat of combustion is channeled into the water until hot water or steam is formed. Hot water or hot steam at a certain pressure is then used to transfer heat to a process. Water is a useful and inexpensive medium for transferring heat to a process. If water were brought to a boil until it became hot steam, its volume would increase by about 1,600 times, producing a power that resembled explosive gunpowder, making the boiler an equipment that had to be very well managed and maintained.

The boiler system consists of: feed water system, hot steam system and fuel system. The feed water system provides water for the boiler automatically according to the demand for hot steam. Various faucets are provided for maintenance and repair purposes. The hot steam system collects and controls the production of hot steam in the boiler. Hot steam flows through the piping system to the pellet machine. In the whole system, steam pressure is regulated using a tap and monitored by means of a pressure monitor. The fuel system is all the equipment used to provide fuel to generate the required heat. The equipment required in the fuel system depends on the type of fuel used in the system.

Indomarine boiler is a type of fire tube boiler where in this type of fire tube boiler, heat transfers from hot gas to water then the water changes to steam. This is because the hot gas from combustion (flue gas) flows through the pipes, the outside of which is covered with water. This type of fire boiler has the characteristics of producing low steam pressure and capacity. The pipe arrangement in the boiler is made pass per pass, the aim is to make the transfer of heat from the gas or fire more efficient. This means that the direction back and forth towards the burner, the three heat has passed through the pipes in the kettle.

The monkey method of this fire tube boiler is that in the pipe an ignition process occurs, then the heat generated in the process is directly conveyed into the boiler filled with water.

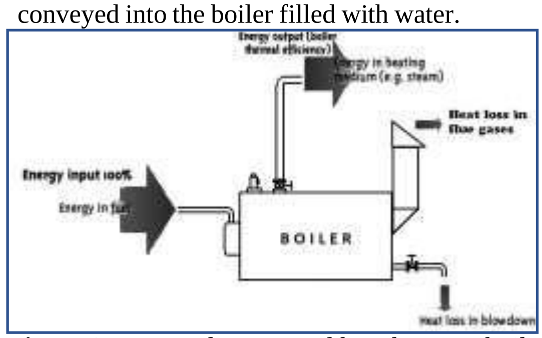

Figure 2. Energy diagram and heat loss in a boiler

Boiler feed water energy can be calculated as follows:

$$Efw =_{fw} x h_{fw} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 4)$$

The energy wasted through blow down is:

$$Ebd = m_{bd} x h_f \dots\dots\dots\dots\dots\dots\dots\dots 5)$$

The steam energy produced by the boiler is:

$$Est = m_{st} x h_g \quad \dots\dots \quad \dots\dots \quad \dots\dots \quad \dots\dots\dots\dots 6)$$

Fuel energy is:

$Ebb = m_{bb} x HHV$ ……. …… ………… …… 7)

The amount of fuel used per hour is:

$m_{bb} = \frac{V_{bb}}{t} \; x \; \rho_{bb}$ ……………………… 8)

So that the boiler efficiency can be calculated as follows:

Efficiency (%) = $\eta = \frac{(Est+Ebd)-Efw}{Ebb}$ ………………. 9)

or,

Efficiency η (%) $= \frac{(m_{st} x h_g)+(m_{bd} x h_f)-(m_{fw} x h_{fw})}{(m_{bb} x HHV)}$ …. 10)

With,

η = boiler efficiency (%)

m_{st} = mass flow rate of steam produced by boiler (kg / hour)

h_g = enthalpy of boiler steam (kJ / kg)

m_{bd} = boiler blowdown mass flow rate (kg / hr)

h_f = enthalpy of boiler blowdown water (kJ / kg)

m_{fw} = mass flow rate of boiler feed water (kg / hour)

h_{fw} = enthalpy of boiler feed water (kJ / kg)

m_{bb} = mass flow rate of fuel (kg / hour)

HHV = calorific value of fuel (kj / kg)

V_{bb} = cubic meter fuel volume

t = time, seconds

ρ_{bb} = density of fuel, kilograms per cubic meter

Boiler Energy Balance can be written as follows:

Qbb = Qu + Qloss .... 11)

Where Qloss is energy lost, kJ / s

3. Research methods

3.1 Research Techniques and Data Collection

The method used in this research includes literature studies in the form of books or journals that discuss the effectiveness of steam distribution and performance in boiler work systems. Method of literature study The literature study in this study, namely the collection of technical data related to the research object that is in the control document of PT. Eastern Pearl Flour Mills and studied various theses, research results, journals, various articles obtained from the internet related to steam performance in pipe distribution systems, especially as a steam supply in the next process, namely the manufacture of a product, in this case, a pellet. This includes scientific papers and other reading sources that support the research and issues to be discussed.

3.2 Technical Data Analysis Techniques

Data analysis using descriptive techniques based on the results of the research conducted. The data obtained from the results of research in the field are then analyzed using the heat transfer formula to look for conduction heat loss, convection, radiation, analyze heat energy at each point in the boiler installation including the distribution of steam by knowing how much mass flow rate is then known how much heat energy is based on the enthalpy for each condition and then conclude the results of the data analysis to determine the problems that occur. Evaluation of the calculation results obtained as one of the inputs and recommendations for improving the efficiency of the steam distribution system.

4. Results and Discussion

4.1 The calculation results

A. Boiler Performance

The Indomarine F-20L boiler is a well designed 3 pass flue gas boiler which transforms to minimize heat loss due to the temperature of the combustion gases going to the outlet. To simplify the calculation, the model is made in 3 sketches with the following assumptions.

a. The kinetic and potential energies in the system are neglected.
b. The value of the flow rate of steam and feedwater wasted in the blowdown system is assumed to be zero.
c. The combustion process in the boiler is operated adiabatically.
d. *Flue gas* and the heat product is modeled as an ideal gas. With the ambient temperature T0 (T0 = 250C)

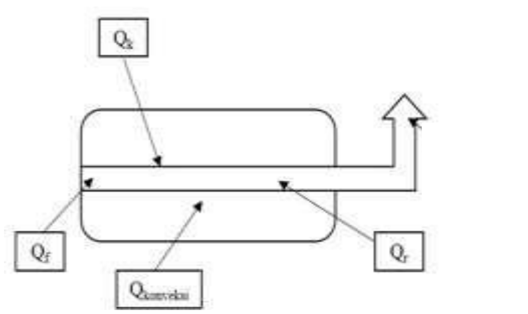

Figure 4.1 Sketch of boiler heat transfer.

Based on the above assumptions, the equation used is as shown below.

1. **Heat entering:**
 Qf = 787,297 x 103 Watt

2. **The rate of heat transfer of conduction, convection and radiation in the fire tunnel**

The hallway and fire pipe materials used in the Indomarine boiler are Seamless Carbon Steel SA 53 Grande B for ASME Section IV boilers, where the thermal conductivity at temperatures of 850 oC for carbon steel is k = 30 W / moC (Table A-2 metal JP Holman).

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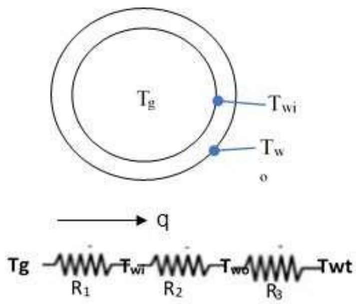

Figure 3. Heat transfer in fire pipes and electrical analogy

2.a. Calculation of the convection heat transfer coefficient in the combustion chamber.

Air is blown by the blower to the burner and then through the flue tube and flowed to all fire tubes. Because it uses a blower, it can be concluded that the heat transfer that occurs in the combustion chamber is the forced convection heat transfer in a rectangular tube.

Reynold's number can be calculated

$$R_e = \frac{Vd}{v}$$

$$R_e = \frac{12{,}41\ x\ 0{,}806}{92{,}463 \times 10^{-6}}$$

$$R_e = \frac{12{,}41\ x\ 0{,}806}{92{,}463 \times\ 10^{-6}}$$

$$R_e = 0{,}1081779\ x\ 10^6 = 108177{,}9$$

Then the Nusselt number can be calculated by equation (5),

$$Nu_b = 0{,}023\ .\ 108178^{\ 0.8}.\ 0{,}554^{0.4}$$

$$Nu_b = 0{,}023\ x\ 10649.06\ x\ 0{,}79$$

$$Nu_b = 193{,}49$$

So that the convection heat transfer coefficient (hf) on the flue tube can be calculated by equation (7), as follows:

$$h_{flue\ tube} = \frac{Nu\ .k_f}{D_1}$$

$$h_{flue\ tube} = \frac{193{,}49\ x\ 0.069}{0.806}$$

$$h_{flue\ tube} = 16{,}56\ W/m^2\ {}^oK$$

Then the calculated value of the resistance is calculated accordingly

$$R_1 = \frac{1}{h_{i\ pipa}\ .\ 2\pi r_1 L_{pipa}}$$

$$R_1 = \frac{1}{16{,}56\ x\ 2.3{,}14.\ 0{,}403\ x\ 3{,}643}$$

$$R_1 = \frac{1}{152.68} = 6.55\ 10^{-3}$$

Then the convection heat transfer rate in the flue tube is:

Q = dT / R

= (1168 - 585.25) / 6,55.10 -3

= 88.97 x 10 3 Watts

2.b Radiant heat transfer.

The rate of radiant heat transfer where a black body is assumed, then:

$Qr = \epsilon_g \sigma A T^4$

Where T burner = 895.6oC = (895.6 + 273) = 1168.6 oK

Thus,

Qr = 0.474 x5,669x10-8 W / m2Kx9.22 m2 x (1168.6) 4 oK = 4,611 x 105 W = 461.1 103 W

3. Calculation of Heat Transfer Rate in Indomarine boiler fire pipe

Known:

Number of pipes: 86 pcs

For fire pipe 1:

a. d1fpi = 47.9 mm = 0.0479 m
b. d2fpo = 50.8 mm = 0.0508
c. L = 5784 mm = 5.784 m
d. Number of pipes = 60

For fire pipe 2:

a. d2fpi = 47.9 mm = 0.0479 m
b. d2fpo = 50.8 mm = 0.0508
c. L = 3322 mm = 3.322 m
d. Number of pipes = 26

3a. Calculation of convection heat transfer in gas flow in the fire pipe

The temperature of the gas flowing in the fire pipe is 1123 oK,

For the gas flow velocity obtained from the laboratory measurement results of 12.41 m / s and the inner diameter of the fire pipe is 80.6 mm. so that Reynold's number (Re) =

$$R_e$$

$$R_e = 0{,}1081779\ x\ 10^6 = 108177{,}9$$

And the Nussest number (Nu)

$$Nu_b = 0{,}023\ .\ 108178^{\ 0.8}.\ 0{,}554^{0.4}$$

$maka\ diperoleh:$

$$h_{i\ pipa} = \frac{20{,}986\ .0{,}0713\ \text{W}/\ m^o\text{K}}{0.0479\ \text{m}} = 31{,}24\ W/m^2\ {}^oK$$

3.b Calculation of convection heat transfer in the fire pipe to the outer flow of the pipe

The temperature of the water flowing outside the fire pipe is 70 oC

The speed of water flow can be calculated by considering the pump data = 2.5 m3 / h = 6.94 10-4 m3 / s

With pipe diameter = 3 "= 7.62 cm = 7.62.10-2 m.

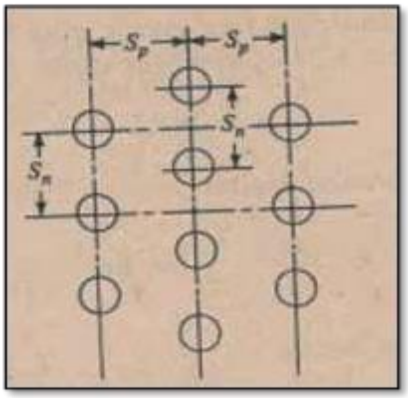

Figure 4. Alternating line tube

Because the pipe is criss-crossed so that: Sp = 90 mm and Sn = 150 mm

So that the convection heat transfer coefficient (ho) on the pipe can be calculated with the following equation:

$$h_{o\ pipa} = \frac{Nu\ .k_f}{n.d_2}$$

Then the calculation of the rate of heat transfer that occurs in the fire pipe is

a. Thermal resistance to pipe outflow convection

$$R_1 = \frac{1}{h_{o\ pipa}\ .\ 2\pi r_2 L_{pipa}}$$

$R_1 = 733{,}5.10^{-4}\ W/^oK$

b. Thermal resistance for pipe conduction

$$R_2 = \frac{ln\, r_2/r_1}{2\pi k_p L}$$

$R_2 = 2{,}932\ x\ 10^{-5}\ W/^oK$= 0.293x10-4 W / oK

c. Thermal resistance to flow convection in pipes

$$R_3 = \frac{1}{h_{i\ pipa}\ .\ 2\pi r_1 L_{pipa}}$$

$R_3 = 0{,}0348\ W/K$ = 348 x 10-4 W / oK

d. Heat transfer losses in pipes

$$q_{pipa} = \frac{\Delta T}{R_{total}\ .\ n}$$

With:

$\Delta T = 765{,}15^oK$

$n = 86\ buah$

$q_{pipa} = 82{,}24\ \ W$

So the total heat transfer in the boiler

= 88.97 x 10 3 W + 461.1 103W + 82.24 W

= 550,152 .kW

3. Calculating the mass balance of steam production

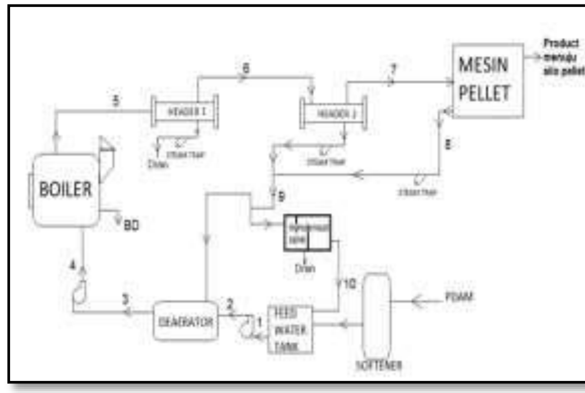

Figure 5. Hot steam production flow from a distributed boiler to a pellet machine

At the beginning of this calculation, we will calculate the steam distribution in the steam distribution system from the boiler through the steam pipe network and to the pallet machine until the steam returns to the feed water tank. Based on the results of measurements made on the Indomarine boiler steam system, the following measurement data are obtained:

a. Softener water mass rate ($\dot{m}_{softener}$) = 982.5 kg / hour

b. The rate of mass of boiler feed water in the deaerator tank ($\dot{m}_{fw}$)= 1126,355 kg / hour

c. Boiler blow down mass rate($\dot{m}_{bd}$) = 192 kg / hour

So that the calculation of this research is carried out by paying attention to the mass balance of each component in the boiler system and in the steam distribution line.

1. Feed water tank

$\dot{m}\ 1 = \dot{m}\ softener + \dot{m}\ 10$

1033.02 kg / hour = 982.5 kg / hour + $\dot{m}$ 10

$\dot{m}$ 10 = 1033.02 kg / hour - 982.5 kg / hour = 50.52 kg / hour

2. Daerator Tank

Mass flow rate in daerator tank:

$\dot{m}_3 = \dot{m}_2 + \dot{m}_{fluid\ from\ the\ pellet\ system}$

1126.35 kg / hour = 1033.02 kg / hour + $\dot{m}_{fluid\ from\ the\ pellet\ system}$

mfluid from the pellet system = 1126.35 kg / hour - 1033.02 kg / hour

= 93.33 kg / hour

3. Boiler

The mass rate of steam produced by the boiler is:

$\dot{m}_{st} = \dot{m}_{fw} - \dot{m}_{bd}$; Where $\dot{m}_{fw} = \dot{m}_4$

$\dot{m}_5 = \dot{m}_4 - \dot{m}_{bd}$

= 1126.35 kg / hr - 192 kg / hr

= 934.35 kg / hour

4. Boiler Header

Mass balance in boiler header

$\dot{m}_6 = \dot{m}_5 - \dot{m}_{drain}$

= 934.35 kg / hour - 46.44 kg / hour

= 887.91 kg / hour

5. Pellet header

$\dot{m}7 = \dot{m}\text{- }6 - \dot{m}\text{steam strap}$

$\dot{m}$ 7 = 887.91 kg / hour - 46.44 kg / hour

= 841.47 kg / hour

6. Pellet Machine

Mass balance in the pellet machine

$\dot{m}$ vapor used for pelleted products = $\dot{m}$ 7 - $\dot{m}$ fluid returns to the boiler system (m8)

= 841.47 kg / hour - 94.06 kg / hour

= 747.41 kg / hour

7. Condensate Collection Tank

Calculate the mass flow rate in the condensate collection tank

a) Feed water tank dimensions

= (W x W x H)

= 600 mm x 600 mm x 800 mm

= 288,000,000 mm^3 = 0.288 m^3

b) The condensate volume rate collected in the feed water tank (Ṿact) = 0.050 m^3 / hour

c) Drain tank mass flow rate (mdrain) = 2 kg / am

d) The density of water (ρair) = 1,000 kg / m^3

The mass flow rate of the condensate to the condensate collection tank is:

$\dot{m}_9 = \dot{m}_{10} + \dot{m}_{drain}$

$\dot{m}_{bct} = \dot{m}_{act} + \dot{m}_{drain}$

Where,

$\dot{m}_{act}$ = Vact x ρair

= 0.050 m^3 / hr x 1,000 kg / m^3

= 50 kg / hour

Thus,

$\dot{m}$ bct = $\dot{m}$ 9 = mact + mdrain

= 50 kg / hour + 2 kg / hour

= 52 kg / hour

B. Calculating Boiler Efficiency:

To calculate boiler efficiency, it is done using an energy balance in order to obtain 'Energy boiler feed water (Efw) of 377723.15 kJ / hour, Energy wasted through blow down is equal to136218.24 kJ / hour and The steam energy produced by the boiler is equal to934.35 kg / hour x 2756.8 kJ / kg = 2575816.08 kJ / hour with the amount of fuel used per hour is 81.95 kg / hour with Fuel energy is3286195 kJ / hour. From that data, the Indomarine Boiler Efficiency is 71.06%.

After the mass rate is calculated, then the energy balance can be determined by calculating the energy contained in fuel, feed water, blow down and steam produced by the boiler..

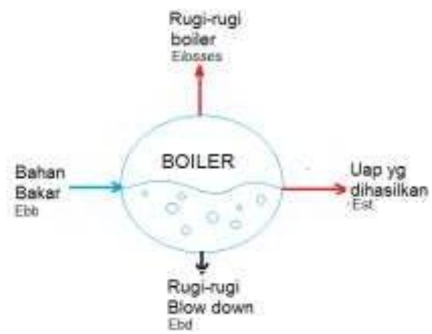

Figure 6. Boiler energy balance

So that the energy balance in the boiler is:

Ebb = Ebd + Est + Elosses

Then the fuel energy (Ebb) is obtained is 912.83 kW, the energy of blowdown (Ebd) is 37.84 kW and the steam energy produced by the boiler (Est) is 715.5 kW.

So that it is obtained Energy losses from operational boiler system itself is 59.49 Kw.

Then to determine the energy balance at the steam distribution load is:

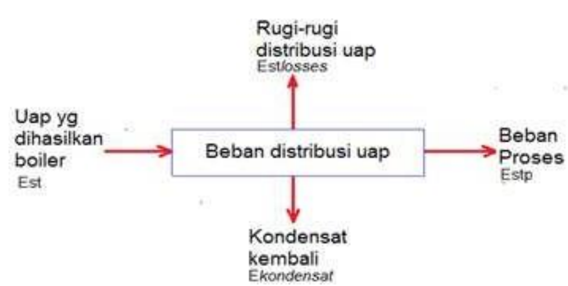

Figure 7. Energy balance in distribution load

From Figure 4.16, the boiler steam energy (Est) is obtained of 715.5 kW, the steam energy used by the pellet machine (Estp) is 634.72 kW

And the fluid heat energy that returns from the pellet machine 25.47 kW

So the energy lost in the steam distribution line is equal to 66.2

4.2 Discussion

Boiler Indomarine at PT. Eastern Pearl flour Mills does not always run every month, but will run according to schedule and performance conditions of the Indomarine boiler. If the Indomarine Boiler does not operate then another boiler which is the Cochran Boiler will operate.

1. **The amount of heat energy loss in the distribution pipeline network**.

When viewed from the comparison between the steam thermal energy value produced by the Indomarine Boiler (Est) and the loss of hot steam in the steam pipe distribution installation. The amount of steam loss in the steam distribution in 2018 to 2020 is shown in Figures 8 to 9 below:

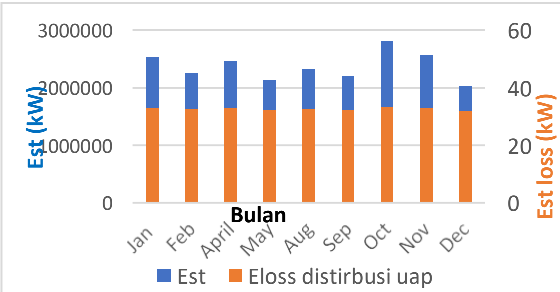

Figure 8. Est Vs Eloss steam distribution in 2018

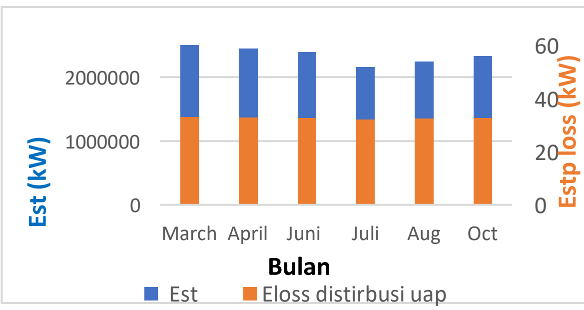

Figure 9. Est Vs Eloss steam distribution in 2019

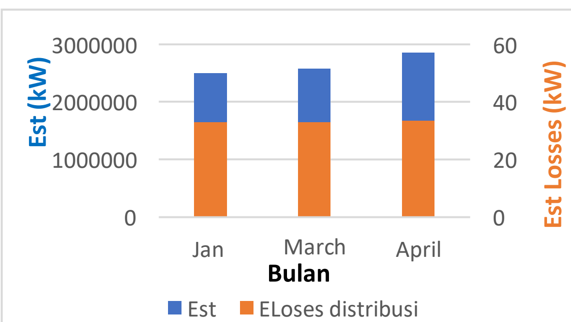

Figure 10. Est Vs Eloss steam distribution in 2020

From Figure 11 to Figure 12, it shows that the greater the production of steam produced by the indomarine boiler, the greater the energy lost in the steam distribution pipeline is 66.2 kW on average. This is because some steam distribution pipes have damaged insulation and have not been repaired. Then some leaks are still visible at several points, especially in the lower area of the pellet silo and header so that the pressure drops, which directly causes the temperature of the distributed vapor to also drop. This can lead to condensate and disruption of the quality of steam required by the pellet machine. It is recommended that steam piping follow proper steam piping rules by taking into account the quality of the dry steam.

2. **Energy balance to see the steam balance that is utilized.**

Based on the results of the calculation of the energy balance in the indomarine boiler installation, that the amount of energy produced by the boiler is equal to the energy released by diesel fuel, this is due to the loss in the chimney pipe, heat loss on the boiler wall, and loss in the blow process. down boiler. The following will be shown the energy balance balance in the steam distribution line produced by the indomarine boiler.

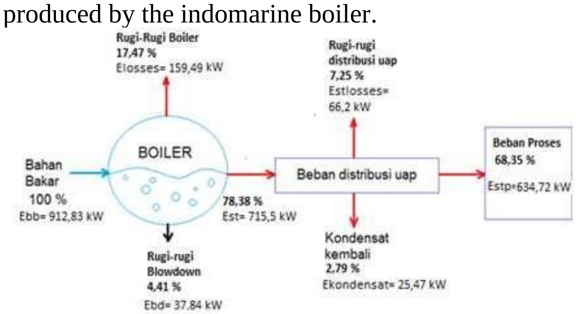

Figure 11. Image of balance of energy utilized by the steam system

3. **Boiler Efficiency**

Indomarine boiler efficiency mostly decreased after 2 months of consecutive use. After cleaning, the performance will again rise above 70%. Some of the things that also cause the efficiency to be less good are because when the boiler does not operate (stop) for quite a long time due to company holidays as seen at the beginning of January 2018 and after the Eid holidays in June 2018 and June 2019 This results in the required preheating is greater because the boiler is in cold conditions and the input water from the daerator has not used the condensate returned from the distribution pipe so that the fuel used is certainly more than usual. From some literature the start up load (warming load) is twice the operating load (running load)

The efficiency of the boiler depends on the level of loading, so try to use the boiler to be operated at the load that provides the highest efficiency at 65-85% of the design capacity.

Figures 12, 13 and 14 also show this and show the amount of efficiency of the Indomarine boiler in 2018-2020 ranging from 67.48% - 72.97%. This illustrates that the performance of the Boiler is below the value of the Indomarine Boiler performance design at 85% (which was obtained in the Indomarine Boiler Manual 20F-L).

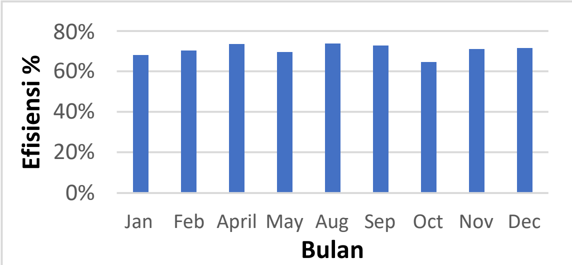

Figure 12. Indomarine Boiler Efficiency in 2018

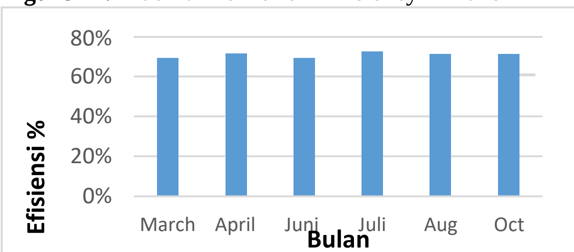

Figure 13. Indomarine Boiler Efficiency in 2019

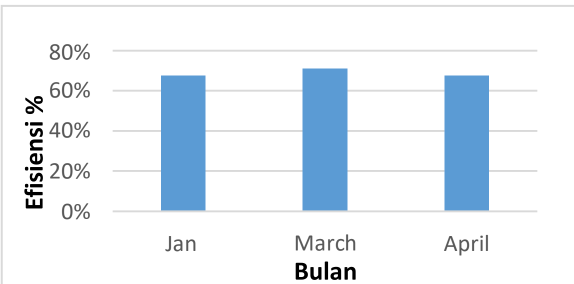

Figure 14. Indomarine Boiler Efficiency in 2020.

4. Conclusion

After paying attention to the results of the calculation analysis and discussion of this study, we can conclude various things, including:

1. In the last three years, heat energy in distribution pipe installations has increased with a heating value of 32.58 (in 2018), 32.68 KW (in 2019) and 33.09 KW (in 2020)
2. With the results of the calculations carried out, it can be seen that 100% of the fuel energy can produce useful steam energy of around 2334311 kJ / hour. Likewise, the mass balance of the working fluid that occurs, the mass rate of feed water used is 1126.35 kg / hour, the mass rate of steam produced is 934.35 kg / hour. While the rest is disposed of through blow down of 192 kg / hour.
3. The boiler efficiency depends on the loading rate on the pellet machine. In the last 3 years, the average Boiler Efficiency shows the efficiency of the Indomarine boiler in 2018-2020 ranges from 67.48% - 72.97%

5. Suggestion

The suggestions conveyed in this study are as follows:

1. Utilizes condensate to the boiler feedwater tank.
2. Selection of boiler operation according to production load.
3. In order to use a steam separator and reduce the number of turns and insulation repairs in the steam distribution line.

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