EVALUATION OF ECONOMIZER HEAT TRANSFER IN BOILER RECOVERY UNITS IN PULP FACTORY

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ABSTRAK

Boiler menghasilkan uap dengan cara menukar panas. Sebagai bagian dari sistem *boiler*, *economizer* membantu memanaskan air umpan yang digunakan. Fungsi *economizer* dan *boiler* diprediksi dapat meningkatkan efisiensi perpindahan panas. Secara khusus, metode penelitian perpindahan panas dan efisiensi *economizer* dari *boiler* pada penelitian ini berada di unit pabrik produksi pulp. Berdasarkan hasil penelitian diperoleh bahwa evaluasi dalam rentang hari kedua hingga keempat, efektivitas perpindahan panas dan koefisien perpindahan panas bernilai rendah. Efektivitas perpindahan panas *economizer* terendah terjadi pada hari kedua sebesar 72%. Sedangkan koefisien perpindahan panas *economizer* terendah pada hari keempat sebesar 925 W/m^2.K. Rendahnya nilai efektivitas perpindahan panas dan nilai koefisien perpindahan panas dapat disebabkan oleh *scalling* pada *economizer* sehingga perpindahan panas tidak maksimal. Semakin besar efektivitas perpindahan panas pada *economizer* maka panas *flue gas* yang terambil akan semakin banyak. Peningkatan perpindahan panas yang maksimal dapat dilakukan dengan melakukan proses *cleaning* untuk menghilangkan *scalling* yang terdapat pada *economizer* agar perpindahan panas antara *flue gas* dan air terjadi maksimal.

Kata kunci: *boiler*, *economizer*, perpindahan panas

ABSTRACT

A boiler generates steam by principally exchanging heat. The economizer helps heat the feed water as part of a boiler system. Economizer and boiler functions predictably can improve heat transfer efficiency. Specifically, this study's research method for heat transfer and economizer efficiency of the boiler is in the pulp production plant unit. The heat transfer coefficient and efficiency were calculated based on water temperature and flue gas entering and exiting the economizer. Based on this research, it was found that during the second to fourth-day evaluation, the heat transfer effectiveness and heat transfer coefficient were low. The lowest economizer heat transfer effectiveness on the second day was 72%. Meanwhile, the lowest economizer heat transfer coefficient on the fourth day was 925 W/m^{2}K. The low value of the heat transfer effectiveness and heat transfer coefficient can be caused by scaling in the economizer, so heat transfer was not optimal. The higher the value of heat transfer effectiveness in the economizer, the more flue gas heat will be extracted. Maximum heat transfer can be reached by the economizer cleaning process to remove the scaling, so heat transfer between flue gas and water occurs maximally.

Keywords: *boiler, economizer, heat transfer*

1. INTRODUCTION

One of the heat exchanger devices used to change the fluid temperature is a heat exchanger using the convection heat transfer method [1]. Heat exchangers often experience a decrease in heat exchanger effectiveness over time as a result of fouling on the walls of the fluid material flowing through the pipe. The amount of heat that will be transferred will decrease if the fouling gets thicker on the walls of the heat exchanger [2]. Therefore, the heat transfer area is an important parameter in the heat exchanger design. The high heat transfer area resulted in a large heat exchanger [3].

A steam boiler or boiler is a heat exchanger that is used to generate steam power [4]. Hot steam originating from heating water was produced by the boiler through burning fuel [5]. Specifically, boilers convert chemical energy from fuel and oxygen into heat energy in the form of steam [6-7]. The choice of boiler fuel requires high calorific value fuel to be able to convert water into steam [8]. The higher boiler feed water produced higher steam.

The boiler has two important parts in its processing, namely the heating furnace for burning fuel in the combustion chamber and the boiler proper for converting water into hot steam [9]. The components contained in the boiler include the ignition furnace, steam drum, superheater, dust collector, safety valve, chimney, superheater, steam drum, and economizer [6]. The most important boiler component used to heat the feed water that will be used in the boiler is the Economizer [10]. Economizer with heating surface 11480 m^2 was used in this research. The heat exchanger system can be seen in Figure 1.

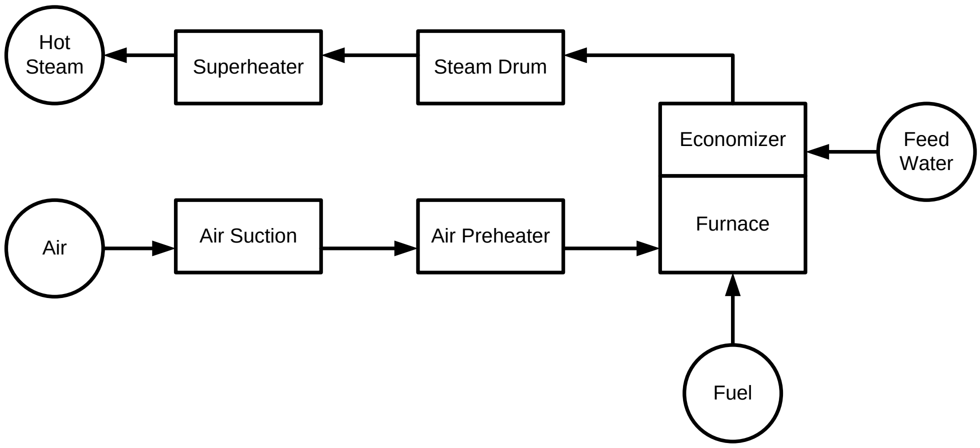

Figure 1. Heat Exchanger System

Before the feed water enters the steam drum, the feed water will be heated in a tubular Economizer. The economizer is used to reduce the fuel used by utilizing the heat from exhaust gas before it is released into the atmosphere [11]. The cost of the fan used to circulate combustion air, and the cost of the pump used to transport feed water into the steam drum are costs that must be covered in economizer cost [10]. The decrease in economizer performance is generally the same as other heat transfer devices usually caused by surface fouling.

In this research, the heat transfer coefficient and effectiveness of economizer in the boiler recovery unit of the pulp factory were investigated. The heat transfer in the economizer is used to increase the boiler feed water temperature to the steam drum to obtain water with the desired temperature condition.

2. METHOD

Effectiveness is a parameter that is used to measure economizer performance. This effectiveness can be calculated from the operating conditions of the water (boiler feed water) and flue gas that enters and exits the economizer. Economizer operation data collection, which water (boiler feed water) and flue gas operating condition data obtained from the economizer unit at PT. Toba Pulp Lestari.

2.1. *Calculation of Heat Transfer Coefficient*

Calculations involved in this topic include Reynold's, Prandtl's, and Nusselts'. Moreover, the effect of the boiling process as the primary heat transfer equation is also available. Here, those will be stated one by one in the equation. Firstly, Reynold's Number Calculation is as follows:

$$Re = (\rho \times v \times d)/\mu \quad (1)$$

where

ρ = density (kg/m^3)
v = fluid flow velocity (m/s)
d = pipe diameter (m)

μ = fluid viscosity (kg/ms)

Secondly, Prandtl's Number Calculation. Prandtl's number was based on Bergman et al. (2011) [12].

$$Pr = (Cp \times \mu)/k \tag{2}$$

where
Cp = specific heat (J/kg.K)
μ = fluid viscosity (kg/m.s)
k = thermal conductivity (W/m.K)

Thirdly, Nusselt's Number Calculation. Nusselt's number formula is as follows:

$$Nu = 0.023 \times Re^{0.8} \times Pr^{n} \tag{3}$$

where
Re = Reynold's number
n = 0.4 to heat the fluid
n = 0.3 to cool the fluid

Fourthly, Heat Transfer Coefficient Calculation. Heat transfer coefficient calculation was based on Setiawan dan Mursadin (2020) [13].

$$h = Nu \frac{k}{d} \tag{4}$$

where
h = heat transfer coefficient (W/m^2.°C)
Nu = Nusselt's number
k = thermal conductivity (W/m.K)

2.2 *Calculation of The Heat Transfer Effectiveness Rates in Economizers*

Then the effectiveness of a working boiler with economizer, the heat transfer effectiveness can be calculated based on Hulu dan Rahmawaty (2021) [14].

$$\varepsilon = \frac{Q}{Q_{max}} \tag{5}$$

where
ε = Heat Transfer Effectiveness Rates
Q = The amount of heat transfer that occurs in the economizer (W)
Q_{max} = The maximum heat transfer that can be achieved by the economizer (W)

3. RESULTS AND DISCUSSION

3.1 *Economizer Heat Transfer Coefficient*

The economizer heat transfer coefficient was shown in Figure 2 which showed that the highest heat transfer occurred on the 6-day which was 980 W/m^2.K. Convection is the heat transfer that occurs in the economizer. Convection can occur because of the difference in temperature between the inner wall surface of the economizer and the moving fluid (water in the economizer tube). Meanwhile, the lowest heat transfer value occurred on the 4-day which was 925 W/m^{2}K. The lower value of the heat transfer coefficient can be influenced by surface fouling so that the resulting temperature can be different every day. Fouling is an impurity like dirt in the economizer. Impurities need to be removed because higher impurities made lower heat transfer [15]. The cleaning process can be carried out using the sootblower process [16]. Sootblower is a maintenance process that aims to remove dirt on heat exchanger equipment [17]. Moreover, the comparison of heat and cold temperatures can be seen in detail in Figure 3.

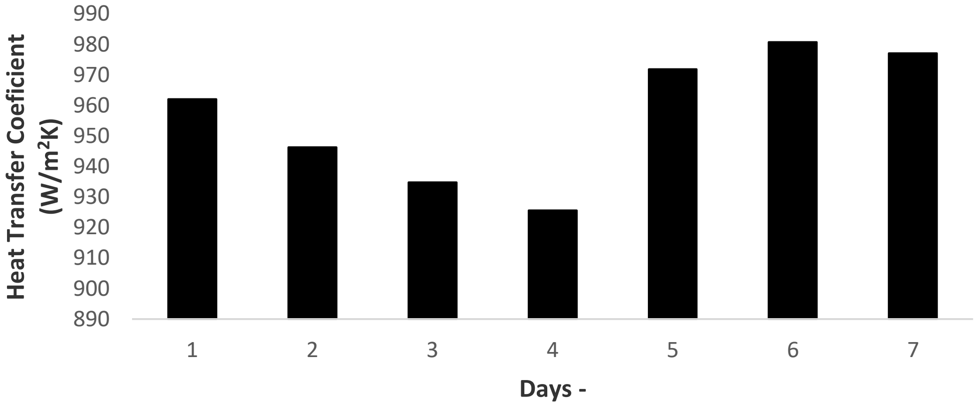

Figure 2. Economizer Heat Transfer Coefficient

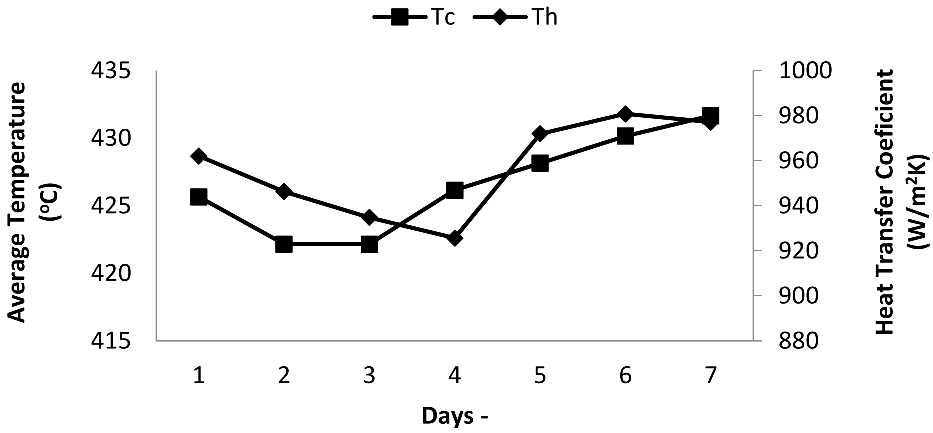

Figure 3. The Effect of Average Fluid Temperature on The Heat Transfer Coefficient

3.2 *Influence of Average Fluid Temperature*

The effect of average water temperature on the heat transfer coefficient can be seen in Figure 3. The heat transfer coefficient in the economizer was determined by the flowing fluid. The higher fluid temperature produced a higher heat transfer coefficient. Meanwhile, lower fluid temperatures produced a lower heat transfer coefficient. Flue gas in this research was used as heating fluid in determining economizer performance. In addition, the heat transfer coefficient can be increased by expanding the heat transfer contact.

3.3 *Economizer Heat Transfer Effectiveness*

The effectiveness of economizer heat transfer can be seen in Figure 4. According to Figure 4, the highest heat transfer effectiveness of the economizer occurred on the seventh day which was 76% and the lowest heat transfer effectiveness of the economizer occurred on the second day which was 72%. The low heat transfer effectiveness value was the same as the heat transfer coefficient value which was influenced by scaling. The change in economizer effectiveness heat transfer showed that the higher effectiveness of economizer heat transfer, the higher the flue gas heat transferred will be. The effectiveness of the economizer heat transfer showed that the amount of energy taken from the flue gas was directly proportional to the total amount of energy absorbed by the water. In addition, the comparison of heat and cold temperatures in this situation is available in Figure 5.

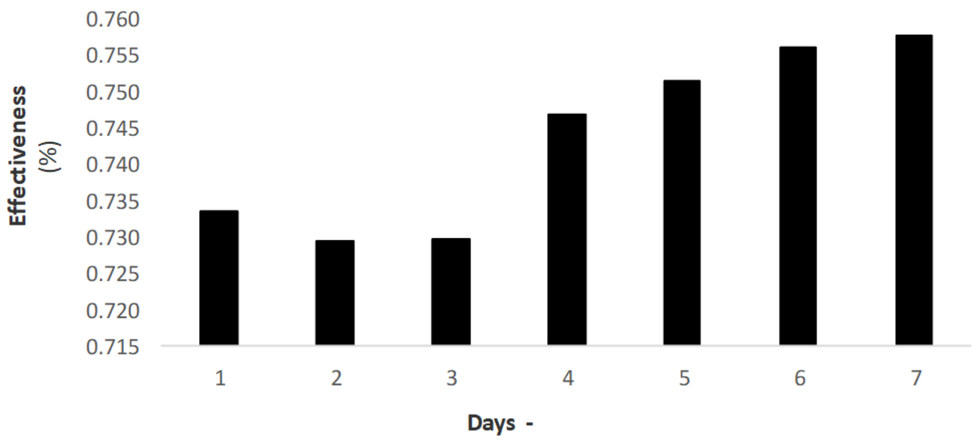

Figure 4. Economizer Heat Transfer Effectiveness

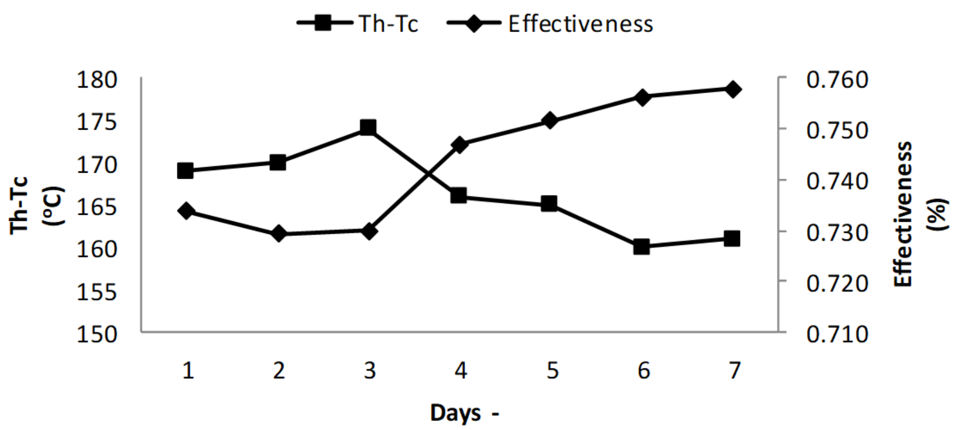

Figure 5. Effect of Inlet Temperature Difference on The Heat Transfer Coefficient

3.4 *Effectiveness of Heat Transfer in the Economizer*

The difference in fluid inlet temperature on the effectiveness of economizer heat transfer can be seen in Figure 5. One of the factors that influences the effectiveness of economizer heat transfer is the difference in inlet flue gas temperature (Th) and inlet feed water temperature (Tc). The temperature conditions of flue gas leaving the economizer indicated the level of effectiveness of economizer heat transfer. The lower temperature of flue gas will increase the effectiveness of the economizer heat transfer and vice versa. The feed water used in the economizer was the water from the demineralization water tank which was pumped from the deaerator. Meanwhile, the flue gas used was gas resulting from combustion that occurred in the furnace of the recovery boiler.

4. CONCLUSION

The heat transfer coefficient and effectiveness of the economizer in the boiler recovery unit of the pulp production factory were investigated in this research. Based on the research results, it was found that the effectiveness of economizer heat transfer and heat transfer coefficient were low on the second to fourth day with values of 72% and 925 W/m^2.K. The lower heat transfer effectiveness and the lower heat transfer coefficient were influenced by scaling so that the heat transfer that occurred was low. The higher effectiveness of economizer heat transfer made higher heat will be taken from flue gas. The cleaning process can be carried out periodically to maximize heat transfer between flue gas and feed water.

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