

Efficiency Analysis of Coal-fired ISGEC Boiler at PT Sukses Mantap Sejahtera Dompu

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Submitted: 20-05-2022

Revised: 30-05-2022

Accepted: 02-06-2022

ABSTRACT: A boiler is a closed combustion chamber to convert air into steam by heating it in the furnace. The steam that is formed from heating in a furnace in water is then used for several company purposes. Likewise, PT SuksesMantap Sejahtera also uses a water pipe boiler as an energy conversion tool. The heat generated by the boiler in the furnace is generated from the fuel combustion process, one of which is coal. To be able to find out the efficiency of the boiler at PT SuksesMantap Sejahtera, the author uses the direct method based on the use of fuel. Based on this research, it can be concluded that the ISGEC (Indian sugar and general engineering corporation) boiler of PT SuksesMantap Sejahtera has an average efficiency of 78.96%. Less coal is used for combustion in the boiler furnace. Then the higher the combustion efficiency obtained.

KEYWORDS: Boiler; Efficiency, PT Sukses Mantap Sejahtera.

I. INTRODUCTION

A boiler is a closed combustion chamber to convert water into the steam by the heat of combustion in the furnace. Steam that is formed from heating in a furnace in water is then used for several company purposes[1]. Several companies in Indonesia use coal as fuel, one of which is PT SuksesMantap Prosperous. PT SuksesMantap Sejahtera is a company that produces crystal sugar cane from sugar cane plants. This company has two kinds of fuel, namely coal and bagasse. The use of bagasse material during the milling period of sugarcane while coal is used when making crystal sugar from raw sugar.

Boiler consists of several types, including fire pipe boilers, water pipe boilers, stoker type boilers, and pulveriser type boilers. Companies usually use water pipe boilers because this type of boiler can operate with very high pressure[2]. Likewise, PT SMS uses a water pipe boiler as an

energy conversion tool. The heat generated by the boiler in the furnace is generated from the combustion process of fuels, one of which is coal. Of the two fuels, namely coal and bagasse, which has a higher heating value is coal. However, from an economic point of view, bagasse is more profitable for the company because it is easy to obtain and free [3]. However, Bagasse is only obtained during the production of crystal sugar so, during the production of crystal sugar, bagasse is not used but uses coal. The process that occurs in the boiler occurs in a cycle which consists of heating, evaporation, steam expansion, cooling, and compression processes. This cycle occurs while the boiler is operating. If the heat transfer to the water produces steam which is increased by 1,600 times, the steam will be produced power like gun powder. This requires the boiler to be managed and maintained very well [4].

The fuel used in the boiler must be in the right amount based on the steam requirements. Calorific value and fuel properties affect boiler performance [5,6]. This affects the efficiency of combustion in the use of fuel. Efficiency is a value that determines the quality of the performance of a machine, where the value of the level of workability is the result of comparing the energy out and energy in. There are things that make it possible to increase the efficiency of the boiler and its additional devices, namely analyzing the possibility of efficiency[7,8]. To be able to find out the efficiency of the boiler at PT SuksesMantap Sejahtera, the author uses the direct method based on the use of fuel. The direct method is used to get efficient value quickly[9,10].

II. EXPERIMENTATION

At PT SuksesMantap Sejahtera, the ISGEC boiler used is a water pipe boiler. This boiler has a capacity of 60 tons/hour fueled by bagasse and 48 tons/hour fueled by coal. The characteristics of this

boiler are using Forced, induced and balanced draft fans to help the combustion process in the furnace. The water used in this type of boiler must also meet certain criteria. The water used must pass the demineralization stage at the demineralized water station. By using sufficient demineralized air and water, boiler efficiency can be increased. Figure 1 depicts the boiler's operation schematically.

Coal is an organic material that is flammable and has a calorific value. The use of coal as boiler fuel has been widely used. Because coal has a limited amount and is expensive, the use of coal is limited. At PT SuksesMantap Prosperous, the

use of coal as fuel is only when producing crystal sugar made from raw sugar. This is because when sugarcane milling is carried out, the fuel used is bagasse produced from the milling station. The specifications for the coal-fired ISGEC boiler can be seen in Table 1.

This research was conducted at PT SuksesMantap Sejahtera in February 2022, when raw sugar activities were carried out at the sugar factory. When the factory produces raw sugar, the boiler station only uses coal as its fuel. This is because bagasse fuel is only used during the milling period.

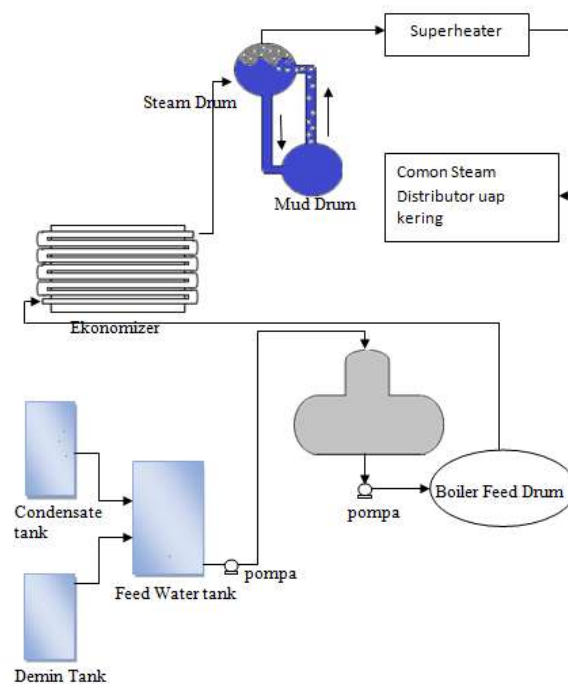


Figure 1. Boiler working process

The stages of the boiler engine work process at PT SuksesMantap Sejahtera start from the feed water tank. The water contained in the feed water tank has previously gone through a demineralization process so that the water has a pH above 8.0. water is sent from the feed water tank using a centrifugal pump to the deaerator to remove oxygen levels that can cause corrosion on the inside of the pipes through which the water passes. After the oxygen is removed from the deaerator, the water will then go through a heating process by passing through the economizer which is then accommodated in the steam drum. In this section, two phases are formed, namely liquid and gas (wet steam). Wet steam will flow to the superheater pipe for further heating (superheater). From this the superheater, dry steam will be produced which will

be channeled for turbine needs and the production process.

This research was conducted to identify the effect of the amount of coal used as fuel on the steam produced and the efficiency that occurs in the ISGEC boiler at PT SuksesMantap Sejahtera. The method used is the actual calculation method called the direct method. Two methods can be used from various sources, namely the direct method and the indirect method. The direct method is applied in this study because this method makes it easier for operators to deal with efficiency problems related to the amount of fuel and steam produced.

In looking for boiler efficiency, there are several methods. One of them is the input-output method. In this study, the parameters for performing calculations using this input-output method are the amount of steam, the amount of fuel, working

pressure, inlet water temperature, type of fuel and enthalpy. This method uses the following equation:

$$\eta = \frac{\text{Heat In}}{\text{Heat Out}} \times 100\% \quad (1)$$

$$\eta = \frac{Q \times (h_g - h_f)}{q \times \text{GCV}} \times 100\% \quad (2)$$

η is the value of boiler efficiency (%); Q is the amount of steam produced per hour (kg/hour); h_g is the enthalpy of saturated vapour (kJ/kg); h_f is the enthalpy of the saturated liquid feed water (kJ/kg); q is the amount of fuel used (kg/hour), and GCV (Gross Calorific Value) is the heat value based on the type of fuel used (kJ/kg).

This method is practical and fast to evaluate boiler efficiency. This is because the calculations used are not too many and the calculation indicators are easy to know [1].

III. RESULTS AND DISCUSSION

Based on Figure 2, at 03.00 and 04.00 there is a decrease in the amount of steam produced, this is because the amount of fuel used is less than at 02.00. Based on Figure 3, the average efficiency of the ISGEC boiler at PT SuksesMantap Sejahtera is 78.96%, and the efficiency of the boiler decreases when it occurs at 05.00. This is because the fuel used at that hour is more than at 04.00 with the steam produced is not too large. Fuel consumption in tons per hour can be seen in Table 2

Table 1. Specification for coal-fired ISGEC boilers

Property	Data
Capacity	48 Tons/hour of coal
vapour pressure	45 bar
Steam temperature	425°C
Inlet water temperature	105°C
GCV worst coal	3805 kcal/kg = 15920.12 kJ/kg
Enthalpy of steam (hg)	3264.95kJ/kg
Enthalpy of incoming water (hf)	440.28 kJ/kg

Table 2. Fuel consumption in tons per hour

Time	Amount of Coal (Tons/hour)	Steam Produced (Tons/hour)
00.00	8.345	37,135
01.00	8,249	36,709
02.00	8,331	37.075
03.00	7,965	35,449
04.00	7,965	35,449
05.00	8.345	37,135
06.00	8090	36,001
07.00	8,328	37,062
08.00	8.348	37,153

Based on the calculation method, namely the direct method. The calculations carried out are used to calculate the boiler efficiency that has been applied to various boiler thermal loads and different proportions of boiler fuel [10]. If a little steam is produced with a lot of fuel, the boiler efficiency obtained will be small. Boiler efficiency can be reduced or increased depending on the amount of fuel used and the GCV content of the fuel. The content of GCV affects the combustion that occurs in the furnace. The poor performance of the boiler can be affected by poor combustion in the furnace. Boiler performance differs by the characteristics of

the coal, with calorific values and properties that will result in different efficiencies. But there are coals with different heating values with the same performance, such as sub-bituminous coal with the heat of 5013 cal/kg with coal of 4852 kcal/kg [6].

Based on the research of Pravitasari et al., 2017 analyzed the efficiency of a boiler machine using the direct method. In this study, the efficiency value obtained was 46%. The decrease in the efficiency of the boiler at that time was caused by the amount of carbon, hydrogen, and sulfur contained in the fuel not burning properly. Meanwhile, in a study conducted by Winarto, 2018

it was stated that complete combustion can be seen from the amount of black smoke that comes out of the flue gas funnel[11]. The more black smoke

produced, the less combustion that occurs in the boiler is not perfect. This indicates the amount of carbon produced as a result of combustion.

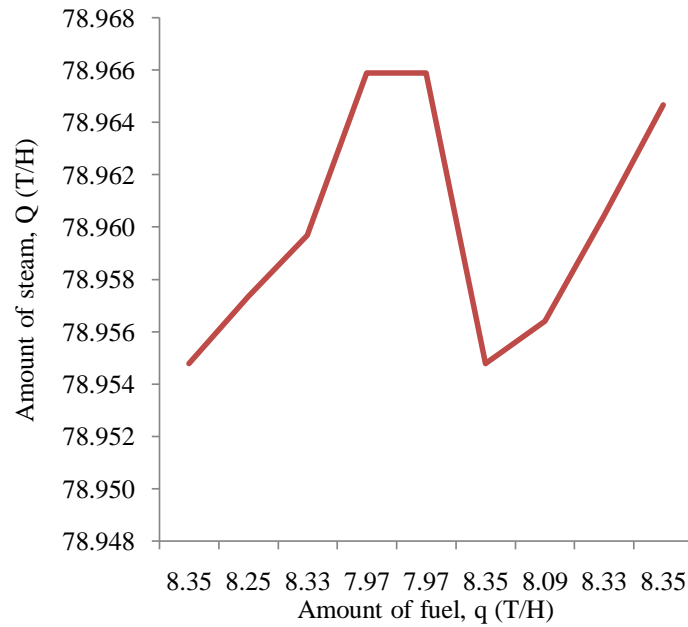


Figure 2. The amount of steam produced is based on the amount of coal fuel used

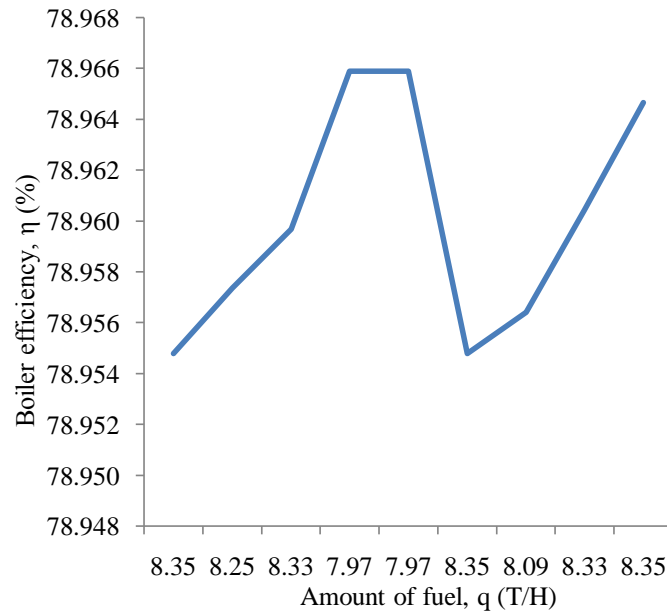


Figure 3. Boiler efficiency based on the amount of fuel

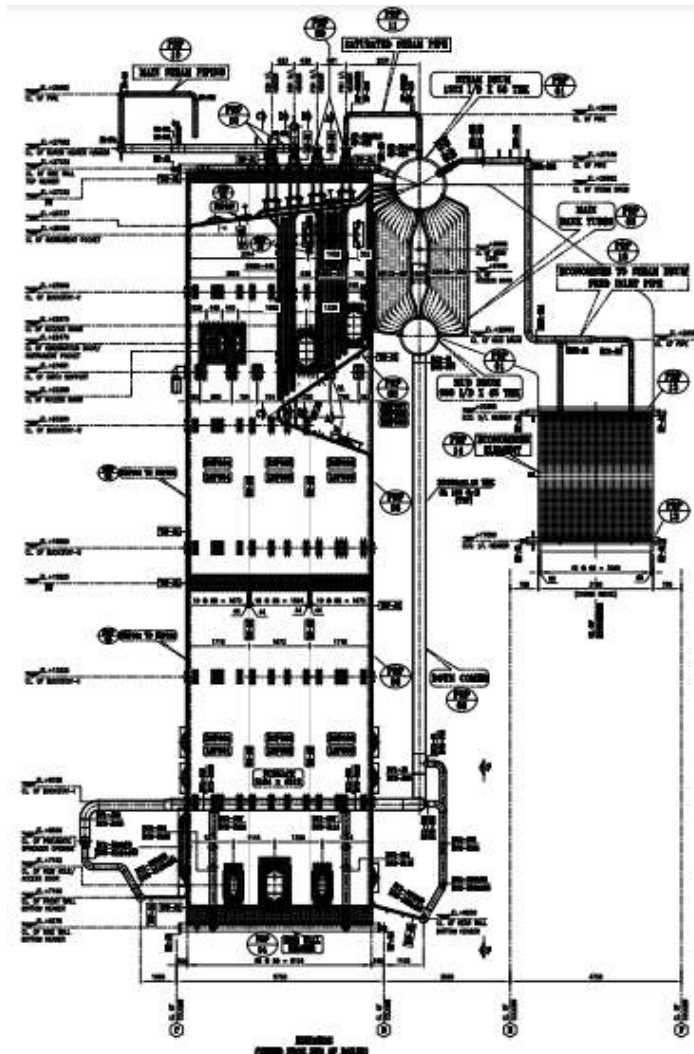


Figure 4 Boiler exhaust funnel at PT SuksesMantap Sejahtera

The black smoke produced in the flue gas funnel which shows the amount of carbon remaining from the combustion can be seen in the exhaust flue gas boiler at PT SuksesMantap Sejahtera. The black smoke that comes out looks clean with a bit of black smoke escaping into the atmosphere. This shows that the combustion that occurs in the boiler looks good. This is also reinforced by the boiler efficiency value which reaches 78.96%. This figure can be said to be high enough to show the efficiency of the boiler. The boiler exhaust funnel at PT SuksesMantap Sejahtera can be seen in Figure 4.

In this study, the hourly GCV of fuel was not checked because the company does not have a heat counter such as a bomb calorimeter, so it uses the average GCV of coal in general. Therefore, the lack of steam produced by a large amount of fuel can be caused by the amount of moisture contained

in the fuel is quite large, resulting in decreased boiler efficiency. This can be seen at 08.00, although the amount of fuel is higher than at 05.00 but the efficiency is at 08.00 is higher. The amount of use of fuel that is not appropriate can also reduce the efficiency of the boiler. This research on boiler efficiency analysis with coal fuel was carried out on boilers located at PT SuksesMantap Sejahtera. The analysis was carried out using the input-output method.

IV. CONCLUSION

Based on this research, it can be concluded that PT SuksesMantap Sejahtera's ISGEC boiler has an average efficiency of 78.96% with the average coal fuel used being 8.22 Ton/hour and the steam produced being 36.57 Ton/hour. Less coal is used for combustion in the

boiler furnace. Then the higher the combustion efficiency obtained.

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