



ANALYSIS THE EFFICIENCY OF BOILER 2011 UA WATER TUBE TYPE AT PT PERTAMINA RU III (PERSERO) PLAJU

by

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ABSTRACT

One of the most important tools in steam production in the oil and gas industry is a boiler. Along with the increasing demand for steam, it is necessary to think about ways to increase the efficiency of the boiler. A boiler or steam boiler is a closed vessel-shaped device used to produce steam or steam. Boilers are designed to transfer heat from a combustion source. With Used the direct method (Direct Method) to calculate boiler efficiency. The pressure and temperature data of the feed water and steam is processed through the data interpolation process to obtain the enthalpy value of the feed water and steam enthalpy. Based on the calculation results obtained boiler efficiency results of 78.11%, 78.27%, and 79.75% with an average efficiency of 78.71%, and from the results of boiler efficiency calculations from the report of PT Pertamina RU III (Persero) obtained results of 89,75% in 1991. The efficiency of the above boiler has decreased by 11.04%. The decrease was caused by several factors, namely shells, valves, and instrumentation that had been eaten by age and damaged tubes.

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1. INTRODUCTION

Increasing demand for energy causes an increase in additional power capacity throughout the world, especially in Industry . One of the most important tools in industrial steam production is the boiler. Along with the increasing demand for steam , it is necessary to think about ways to increase the efficiency of the boiler. boilers are needed for the future to avoid energy wastage.

Efficiency Boiler is a quantity that shows the relationship between the incoming energy supply into the boiler and the output energy produced by the boiler. Combustion Efficiency Boiler in general describes the ability of a burner to burn all of the fuel that enters the furnace) boiler. efficiency Boiler is calculated from the amount of unburned fuel together with the amount of residual combustion air (excess air). combustion Boiler can be said to be efficient if there is no fuel left at the output end of the boiler, as well as the amount of residual air (Sugihartono, 2020).

Boiler or boiler is a closed vessel-shaped device used to produce steam or steam. Steam is obtained by heating water in a vessel with fuel. steam will be used to drive a turbine coupled to a generator. The boiler converts chemical energy into other forms of energy to produce work. Boilers are designed to transfer heat from a combustion source, which is usually in the form of fuel combustion (Purba, 2015).

In compiling this research, the authors limit the main issues regarding the efficiency Package Boiler type Water tube at PT Pertamina RU III (Persero) Plaju.

The objectives of this study are as follows:

1. To study the working principles of Package Boiler type Water Tube at PT Pertamina RU III (Persero) Plaju.
2. Studying the efficiency analysis Package Boilers type Water Tube at PT Pertamina RU III (Persero) Plaju.

The benefits of this research assignment are as follows:

1. Can understand the working principle of Boiler Package type Water Tube at PT Pertamina RU III (Persero) Plaju.
2. Can understand the efficiency analysis of Boiler Package type Water Tube at PT Pertamina RU III (Persero) Plaju.

2. LITERATURE REVIEW

Heat Transfer Heat

Transfer is the transfer of energy due to a temperature difference between two different places, heat will flow from a place with a high temperature to a place with a low temperature, in other words heat transfer is the study of the rate of heat transfer between material or object due to differences in temperature (hot and cold temperatures).

Conduction Heat Transfer Heat

Transfer by conduction is a process of heat transfer if heat flows from a place with a high temperature to a place with a lower temperature; still the medium for heat transfer is fixed.

Convection heat

Heat transfer is a transfer of heat through the flow of the medium also moves.

Radiation Heat

Heat transfer is heat transfer that occurs due to emission or light and radiation of electromagnetic waves.

Types of Heat

Heat is defined as the heat energy possessed by a substance. Heat can be divided into two:

1. **Sensible Heat substance**
Receives heat it will experience an increase in temperature, but sensible if the substance releases sensible heat then the temperature will decrease
2. **Latent Heat (Latent Heat)**
If a substance or object receives or releases heat which causes a change in the form of the object or substance but does not cause a change in temperature

Steam

Steam is the technical language of water vapor, namely the gaseous phase of water which is formed when water boils:

1. **Saturated Steam**
Saturated Steam wet or steam is steam produced from the steam first level a boiler where the temperature usually ranges from 150 to 300°C.
2. **Superheated Steam**
Superheated steam is steam made from saturated steam which is reheated in a boiler to a temperature of $\pm 700^\circ\text{C}$.

Boiler

Boiler or steam boiler is a device in the form of a closed vessel used to produce steam or of a boiler is expressed as the ratio of the heat used to heat water and the formation of steam to the heat produced by burning fuel. The boiler components include: Economizer, combustion chamber, Burner, Steam Drum, Superheater, Chimney (stack) Force Draft Fan, Water Drum, Air Fan seal.

Components Boiler:

1. Boiler Classification a) Fire Tube Boiler

In a fire tube boiler, the fluid flowing in the pipe is flame gas (combustion products), which carries heat energy (thermal energy) and will be transferred to the water in the boiler through the heating surface.

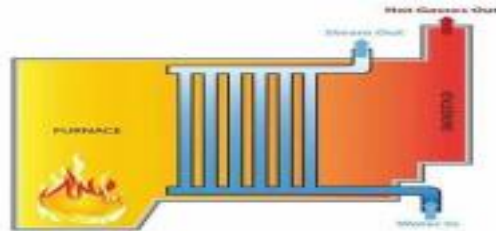


Figure 2.2 Fire Tube Boilers b) Water Tube Boiler



In a water tube boiler, the fluid flowing into the pipes is water. Heat energy will be transferred from outside the pipe (combustion chamber) by combustion gas to water and will heat water to become steam which will enter the steam area in the drum

Boiler Efficiency is

Boiler efficiency defined as the percentage of fuel heat energy (heat input) that is used effectively in steam produced or in other terms of efficiency, efficiency in a boiler is the percentage of work or level for boiler obtained from the comparison between the energy transferred to the working fluid or absorbed by the working fluid in the boiler with the input of fuel heat energy.

Main Materials and Supporting

Materials the main raw materials used are water, air and natural gas. Water is used as the main raw material to produce steam or steam. Steam functions to rotate the turbine blades. The process is water is heated to become steam then the steam is condensed into water by the condenser.

The water used is demineralized, which is water free of salts and mineral elements and has a conductivity (ability to conduct electricity) of $\leq 0.2 \mu\text{S/cm}$ (microsiemens per centimeter). The steam production process requires fuel. The fuel used is natural gas.

3. RESEARCH METHOD

Time and Place

Data collection was carried out at PT. Pertamina RU III (Persero) Plaju from 01 June 2022 to 30 June 2022. Research time is from July to August 2022.

Research Method

In collecting this data apart from using the right method, it is also necessary to choose relevant data collection techniques, so that the adaptation process it can process relevant data and results. Data collection techniques used in this study is:

Data Collection

Is a way to obtain the data needed by the author in the final project, namely through several methods:

a. Literature Study

Of theories and research concepts related to the research to be carried out. The literature study examined regarding boilers was sourced from several books at PT. Pertamina RU III (Persero) Plaju, as well as e-books and internet journals.

b. Observation Method

Is a method used to obtain data obtained directly from the object under study. So get the necessary data.

c. Interview Method

A method of collecting data through interviews or question and answer directly from the agency or company workers to obtain the necessary data.

d. Internet Searching

Internet searching or online searching is a search using a computer that is carried out via the internet with certain search tools or software on servers connected to the internet that are scattered in various parts of the world.

Writing Flowchart The writing

Method in question is a systematic step in the initial stages of writing until the writing is completed, while the method is as follows.

1. Field studies and literature studies
2. Observations Data Collection Calculations and Data Analysis
3. Conclusions and Suggestions
4. Figure 3.1 Schematic of Calculation of Boiler

Efficiency Boiler

Calculation of the efficiency boiler package type water tube carried out using the Direct Method using the following formula:

a. Calculation of Boiler

$$\frac{Q_2 - Q_1}{Q_2} \times 100\%$$

Q2 = Feed Water Flow X Feed Water Enthalphi

4. RESULTS AND ANALYSIS

Operation Data and Calculation

a. Calculation of the heat contained in the *steam*

$Q_1 = \text{Steam Flow} \times \text{Enthalpy Steam}$

b. Calculation of *Low Heating Value (LHV)* from Gas Fuel

$Q_3 = \text{Total fuel gas requirement} \times \sum \text{LHV}$

c. Calculation of total fuel

Requirements Total fuel gas requirements = Fuel gas requirements to the pilot burner + fuel gas flow to the main burner.

d. *Sensible heat of feed water*

Operational data at PT Pertamina RU III (Persero) Plaju used to calculate *boiler* on the 1st - 30 June 2022 are as follows:

Table 4.1 Operational Data of Boilers PT Pertamina RU III (Persero) Plaju

A. Boiler Feed Water

	Date 13	Date 14	Date 15
T °C	118.14	118.13	118.13
Pressure kg/cm ²	80 .76	79.60	79.86
Flow Tons/Ho ur	42.11	42.21	43.85

B. Steam

	Date 13	Date 14	Date 15
T°C	381.66	383.04	383.4
Press ure kg/cm ²	36.46	36.81	37.57
Flow Tons/ho ur	40.80	41.15	42.18



C. Analysis of fuel gas components

Komponen	%mol	BM (g/mol)	%BM	%Berat	NHV (kcal/kg)	HV (kcal/kg)
CH ₄	80,637	16	12,902	61,567	11954	7359,719
C ₂ H ₆	6,35	30	1,845	8,804	11353,52	999,564
C ₃ H ₈	4,36	44	1,918	9,153	10780,84	986,77
iC ₄ H ₁₀	0,763	58	0,443	2,114	10936,52	231,198
nC ₄ H ₁₀	0,946	58	0,549	2,62	10936,52	286,537
iC ₅ H ₁₂	0,333	72	0,24	1,145	10842	124,141
nC ₅ H ₁₂	0,22	72	0,158	0,754	10842	81,749
CO ₂	6,593	44	2,901	13,845	-	-
Total	100	394	20,956	100		10069,678

Table 4.2 Package Boiler 2011 UA

Data dated 13th

Keterangan	Q in Kkal/jam	Q out Kkal/jam
Perhitungan panas masuk		
Panas pembakaran bahan bakar	33.293.175	
Sensible heat air umpan	4.989.908,67	
Perhitungan panas keluar		
Panas yang dikandung produk steam		30.998.248,8

Data dated 14th

Keterangan	Q in Kkal/jam	Q out Kkal/jam
Perhitungan panas masuk		
Panas pembakaran bahan bakar	33.494.568,5	
Sensible heat air umpan	5.001.294,06	
Perhitungan panas keluar		
Panas yang dikandung produk steam		31.218.653,3

Data dated 15th

Keterangan	Q in Kkal/jam	Q out Kkal/jam
Perhitungan panas masuk		
Panas pembakaran bahan bakar	33.595.265,3	
Sensible heat air umpan	5.195.611,1	
Perhitungan panas keluar		
Panas yang dikandung produk steam		31.990.788,3

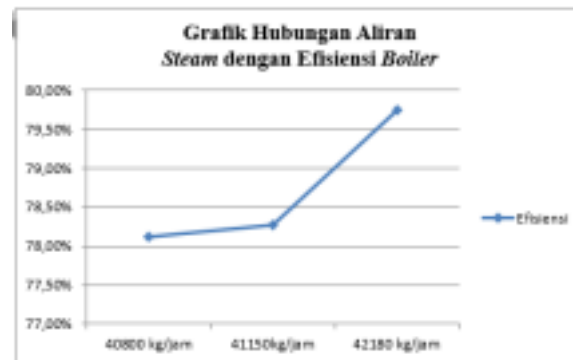
Determining the efficiency of a boiler can be done by compare the heat absorbed with the total heat entering the boiler. From these calculations, the efficiency for the 2011 UA Package boiler at the refinery unit at PT Pertamina RU III (Persero) on 1 June 2022 – 30 June 2022 is an average of **78.71%**

Discussion

The following is a graph of the relationship between steam efficiency boiler at PT Pertamina RU III (Persero) Plaju on 13, 14 and 15 June 2022

Table 4.3 Relationship of Steam Efficiency Boiler

Date	%	Flow Steam
13	78.11%	40800 kg/hour
14	78.27%	41150 kg/hour
15	79.75%	42180 kg/hour



On the first day, an efficiency of 78.11% was obtained with *steam flow* of 41000 kg/hour. On the second day, an efficiency of 78.32% was obtained with *steam flow* of 41110 kg/hour. On the third day, an efficiency of 79.17% was obtained with *steam flow* of 41640 kg/hour.

It can be seen in the graph above that the efficiency increases together with the *steam flow*, and it can be concluded that the higher the *steam flow*, the efficiency also increases, this is also supported by combustion heat, although *steam flow* increases if the combustion heat provided is still low then efficiency cannot experience increase, combustion efficiency can be increased by maintaining *supply* to the burner so that the air balance ratio is needed to ensure that the fire remains in perfect combustion.

CONCLUSION

Based on research that has been carried out on *the 2011 UA package boiler* at PT Pertamina RU III (Persero) Plaju, the following conclusions can be drawn:

1. The working principle of *the 2011 UA package boiler* at PT Pertamina RU III (Persero) Plaju is the process of heating water to change phase to steam.
2. From the calculation results, the efficiency value of *the 2011 UA boiler package* at the refinery unit at PT Pertamina RU III (Persero) Plaju with an average of 78.71%, and from the *boiler* from the PT Pertamina RU III (Persero) report obtained a yield of 89.75% in 1991. From the calculation results, the efficiency value of *the 2011 UA boiler package* at the refinery unit at PT Pertamina RU III (Persero) Plaju with an average of 78.71%, and from the results of the efficiency calculation *boiler* from the report of PT Pertamina RU III (Persero) a yield of 89.75% was obtained in 1991.



Suggestions

Based on the discussion and conclusions from this, there are several suggestions including the following:

1. In order to obtain good boiler efficiency, it is necessary to pay attention to operational standards starting from the procedure is then a preliminary inspection, carrying out operations to the maximum
2. Pay attention to the quality of feed water, because feed water that meets specifications can make equipment in the *boiler* lasts a long time, and don't forget to always carry out routine checks so that the quality of feed water is maintained.

REFERENCES

- [1] Adli, Zul, et al. 2018. Performance Analysis of the Takuma N-600 SA Boiler with a Steam Level of 20 Kg/cm^{2/259}OC Fueled by Computation-Based Fiber and Palm Oil Shells. Aceh: Lhokseumawe State Polytechnic.
- [2] Kharisma, Aji Abdillah, and Arif Budiman.
- [3] 2020. Calculation of the Efficiency of Fire-Tube Boiler Machines Using the Direct and Indirect Methods for Granular Pellet Products. West Jakarta: Gunadarma University. Muin A, Syamsir. 1998. Energy Conversion I (Steam Kettle). Jakarta : Rajawali Press Publisher.. Perry, KH, and Clinton, CH, "Chemical Engineering's Hand Book," 1989, 6thedition, Mc Graw Hill Kogakusha ltd, Tokyo
- [4] Purba, Jhonas. 2015. Design of a Fire Pipe Boiler for Boiling Soybean Porridge in the Tofu Industry with a Saturated Steam Capacity of
- [5] 160 kg/hour. Riau University of Pasir
- [6] Pengaraian
- [7] Raharjo, WD, and Karnowo. 2008. Energy Conversion Machine. Semarang : Semarang State University.
- [8] Renata, Leny EP 2013. Unit 3 Condenser Efficiency. Palembang : State Polytechnic of Sriwijaya Palembang.
- [9] Sugihartono, A. 2020. Calculation of Boiler Efficiency by Direct Method in Fire Pipe Boilers. Blora: PPSDM MIGAS Cepu.
- [10] User's Manual, "Preelementary Offsite & Utilities Operating Manual'MW Kellog Plant Service. October. 1984

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