JOURNAL OF MECHANICAL SCIENCE AND ENGINEERING
Vol.1 No.1 October 2013

# Influence of Blending of Diesel Certified and Biodiesel CPO on Efficiency of 60 MMT SB Boiler Type

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**Article history**

Received XXXX
Received in revised form XXXX
Accepted XXXX

**Abstract**

Combustion is chemically the process of mixing oxygen and carbon and produces heat. Oxygen is extracted from air while carbon derived from fuel. Combustion in a boiler is a chemical process of unification of the fuel and oxygen that produces heat energy. Calculation of the combustion process is the starting point when on design a boilers, furnaces and other appliances that generate heat from the combustion process.. This study analyse the fuel that is a mixture of Diesel fuel and biodiesel fuel derived from crude palm oil. Biodiesel was mixed with diesel fuel and the mixture fuels were ultimately obeserved element content for some variable composisiton of biodiesel in mixture fuel. This mixture fuel was as burning media in boiler. The analysis show that when the more the composition of biodiesel give a reduction of element of $SO_2$, CO, $NO_x$ in exhaust gas of boiler while the maximum boiler efficiency is 85.637% for mixture fuel of 20% biodiesel composition.

*Keywords*: *Solar Certified, CPO Biodiesel, Fire Tube Boilers, Emissions, Efficiency*



## 1. INTRODUCTION

The need of fuel increases every year with the developing of a nation. This increase is due to the rising of population accompanied by increasing public welfare which certainly impact on increasing the need for industrial and transportation activities. Meanwhile, fuel oil, that is a main fuel consumpted by people every day, is limited in stock. The fuel oil is not sustainable for a long time. The petroleum reserve continue to decline and finally finished [6]. Recently we can observe that all combustion process occur in all day life like industries and transportation engine take a large part of fuel consumption. Besides that, the combustion sector in houses like cooking and others applications use fuel gas as the combustion agent. All the combustions process produce at leat $CO_2$ and $H_2O$ (complte combustion). In fact all flue gas produce dangerous gases to human body like carbon monoxide CO, sulfurdioksida $SO_2$, hydrocarbon HC and nitrogen dioxide $NO_2$.

The process of blending certificated Diesel fuel and biodiesel derived from crude palm oil are aimed to find the number of elements involved in chemical reaction and to know the heat generated in combustion. The another part it is observed the efficiency of fire tube boiler when it use the above fuels. The hypothesis of this case are :

- Based on the principlee of thermodynamics in boiler that boiler operates on the combustion temperature and vapor pressure which are only influenced by the specific exhaust gas temperature.
- Ratio of fuel oil and air is the most important parameters that influence the efficiency of a boiler.
- Temperature of exhausts gas should be as low as possible to find the optimal boiler efficiency.

The boiler was a closed vessel type where water receive heat of combustion and then occur phase changes to steam. A system consisting of water

systems and fuel system and feed water systems work together to provides steam.

In fire tube boiler, boiler tube filled with flowing hot gas and water is in the outside part of tube, where this system is covered by a shell..The fire in boiler tube used to increase the capacity of water to change it pahse to steam. The values of steam pressure range from small range to moderate value.. The capacity of boiler produces 12000 kg/hr with pressure about 18 $kg/cm^2$. This boiler use commonly fuel oil, gas or solid fuel as combustion agent.

In water tube boiler, boiler tube filled with flowing water and the flame flow at the outside part of the tubes. The water that evaporate comes to header and then collect in steam drum. This type of boiler produces high steam pressure and it is designed with capacity of 4500-12000 kg/hr.

. The efficiency of a boiler depends on the amount of heat loss. The heat loss of each part of boiler can be theoritically calculated. The heat losses in a boiler are due to the following reasons :

- Exhaust gases in chimney
- Evaporation of water formed from fuel.
- Evaporation of water levels in fuel.
- Water content in supply air
- Radiation
- Other heat losses.

Diesel fuel is used for Diesel engine which operates up to 1000rpm. Diesel fuel has the boiling point from 260 to 315$^oC$. The main parameters of Diesel fuel are :

- Components of fuel ( C, H, S, ash, the water content).
- Components gas emissions.
- Temperature of exhaust gases.
- Ambient temperature.
- Gross Calorific Value.

The alternative fuel of Diesel fuel is biodiesel which made from vegetable oils. This alternative fuel produces low level of pollution in atmosphere when it is burned. The fuel is one of which produces the friendly exhaust gases. Some advantages of Diesel fuel as follow :

- The use of biodiesel can extend the life time of Diesel engines because it has a characteristics of it lubrication [5].
- Biodiesel is not poisonous for people
- Biodiesel has high cetane number.

Some disadvantages of Diesel fuel derived from vegetables oils are :

- More expensive than regular Diesel fuel.
- Less suitable for use in low temperatures.
- It can not be transported by pipeline.
- It can only be used for a diesel engine
- It causes the old engine easy to corrode
- Unsuitable in the cold condition. [6].

The other parts, the characteristics of biodiesel emission [5] when it burn are :

- The emission of carbon dioxide decreases.
- Sulfur dioxide emissions decreases.
- The content of ash decreases.
- The emission of carbon monoxide decreases.

Oil solar is commonly called High Speed Diesel ( hsd ) fuel or automotive Diesel oil (or gas) or marine oil ( mgo ). The fuel is used in Diesel engines that is suitable for rotation ofengine than 1000 rpm. The another Diesel fuel is called fuel oil and it is used to low speed with rotation less than 300 rpm. The last one, is Diesel oil or diesel fuel commonly called industrial diesel oil ( iddo ) and used for a Diesel engine which is suitable for rotation from 300 to 1000 rpm.

The Combustion occurs very rapid and the reaction between fuels with oxygen occurs very fast. It is very important reaction among the chemical process in producing $CO_2$, $H_2O$, and sometimes also CO which depends on the condition of burning. The fuel contain sulfur and $SO_2$.The use of solar as fuel in Diesel engines produces exhaust gas contain $NO_x$, $SO_x$, hydrocarbon and particles [6].

From the background above, this study will be focussed on the following items;

- Characteristic of blending diesel certificated and biodiesel derived from crude palm oil is not yet many explanations in literature.
- In processes of blending diesel certificated and biodiesel crude palm oil in combustion have a lot of explaining theoretically.

The purposes of this research are as follow

- To develop emissions data of exhaust gas and efficiency of boiler.
- To produce blending components diesel crude palm oil certificated and biodiesel.
- To give characteristics of burning the fuels in a boiler

## 2. TESTING PROCEDURES

Biodiesel of crude palm oil (CPO) material is very potential to replace the fuel diesel. The certificated Biodiesel crude palm oil and diesel certificated mixed with variations from B0 until B30 and tested in fire tube boiler to find flue gas components by means the following procedures.

Testing composition of fuel conducted in Pertamina. Every sample is placed in a measuring glass. The symbol B0 means the biodiesel derived from crude palm oil cpo about 0 ml, mixed with diesel certified of 1000 ml of biodiesel. B5 means 50 ml mixed with diesel certified 950 ml, a biodiesel B10 =100 ml mixed with diesel certified 900 ml, samples B15 = biodiesel 150ml mixed with diesel oil 850 ml, certified a biodiesel B20 = 200 ml certified 800 ml mixed with diesel , samples B30 = biodiesel cpo 300 ml mixed with diesel certified 700 ml stirred mixture of their use stirrer for 30 minutes. The Following

results of the sample tested is shown in Table 1 and the result of flue gas measurements is shown in Table 2.

Gas emissions analysis was conducted in the laboratory of biodiesel at Sriwijaya University Indralaya. The combustion of fuel was conducted in fire boiler tube type SB 60 MMT. The fuel samples were tested in the same laboratory to analys the ultimate fuel. The result of composition of exhaust gases, gas temperature, environmental temperature, combustion temperatures O2, $CO_2$, CO $NO_x$, $SO_2$ were measured.

## 3. RESULTS AND DISCUSSION

The results of ultimate fuel analysis is presented in Table 1 and Table 2. The variables B0, B5, B10, B15, B20, B30.

Table 1. The results of ultimate fuel

| No. | Element | Unit | Standard of Solar | B0 | B5 | B10 | B15 | B20 | B30 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Carbon | (% w) | 83 -87 | 87.00 | 86.00 | 85.70 | 85.50 | 85.20 | 85.00 |
| 2 | Hydrogen | (%w) | 10 - 14 | 11.00 | 12.00 | 12.30 | 12.30 | 12.30 | 12.00 |
| 3 | Sulfur | (%w) | 0.05 -6 | 0.500 | 0.098 | 0.093 | 0.090 | 0.085 | 0.075 |
| 4 | Ash | (%w) | Max 0.01 | 0.009 | 0.010 | 0.015 | 0.017 | 0.018 | 0.020 |
| 5 | Inert gas | (%w) | | 1.491 | 1.892 | 1.982 | 2.093 | 2.397 | 2.905 |
| 6 | GCV | kkal/kg | | 10581 | 10583 | 10675 | 10336 | 10338 | 10370 |
| 7 | Water content | ppm | Max 500 | 4.5 | 4.8 | 5.2 | 5.5 | 5.7 | 5.9 |
| 8 | Spgr 60/60F | | | 0.857 | 0.8586 | 0.8583 | 0.8589 | 0.8596 | 0.8609 |

Table 2. The Data testing gas emissions

| Component | Unit | B0 | B5 | B10 | B15 | B20 | B30 |
|---|---|---|---|---|---|---|---|
| Stack Temperature | $^0$C | 179.50 | 179.94 | 180.00 | 181.02 | 180.91 | 181.20 |
| Temperature Condition | $^0$C | 27 | 27 | 27 | 26 | 27 | 28 |
| Combustion Temperature | $^0$C | 300 | 300 | 315 | 318 | 330 | 340 |
| $O_2$ | % | 7.5 | 7.6 | 7.8 | 7.9 | 8.2 | 8.5 |
| $CO_2$ | % | 9.7 | 9.9 | 10.0 | 10.1 | 10.7 | 11.1 |
| CO | % | 0.0563 | 0.0563 | 0.0564 | 0.0564 | 0.0565 | 0.0562 |
| $NO_x$ | % | $2.1x10^{-4}$ | $2.1x10^{-4}$ | $2.2x10^{-4}$ | $2.2x10^{-4}$ | $2.5x10^{-4}$ | $2.0x10^{-4}$ |
| $SO_2$ | % | 0.0020 | 0.0022 | 0.0021 | 0.0019 | 0.0017 | 0.0016 |
| Excess Air | | 1.57 | 1.57 | 1.58 | 1.58 | 1.59 | 1.56 |

From the research, we compare the performance of diesel fuel and biodiesel crude palm which were used as fuel fire boiler tube type SB 60 MMT. So we can evaluate stochiometri reaction, using combustion calculation theoretically. We calculate $CO_2$ content, excess air, gas emissions, and efficiency by using the method indirect or heat loss.

The rsults showed that the decrease in the efficiency of boilers caused by some factors. The heat losses is largest because of the exhaust gases and of forming of evaporation of water $H_2O$ in fuel. Figure 1 shows the data about experiments of fuel from B0 until B30 ; that is, the comparaison between the oxygen calculated theoritically and measured in boiler combustion. The theoritic values tend to decrease with composition (B0 – B30) starting at B15. This is in contrary with experimental results.

We can see in Figure 2 that the percentage of excess air decrease with composition of fuel. for theritical calculation. But the experimental results seem to be constant profile of excess air. Figure 3 shows that the $SO_2$ ( experiment $SO_2$ ) content is theoretically very small in quantity. This is because many biodiesel vegetable oil cpo is environmentally friendly. By using the method indirect or method of heat loss can be seen from Figure 4.

Figure 4 can shows that due to heat loss in dry exhaust gases (Q1) is higher and heat loss due to evaporation of water in fuel (Q2) is lower. This decrease has an impact on boiler's efficiency.

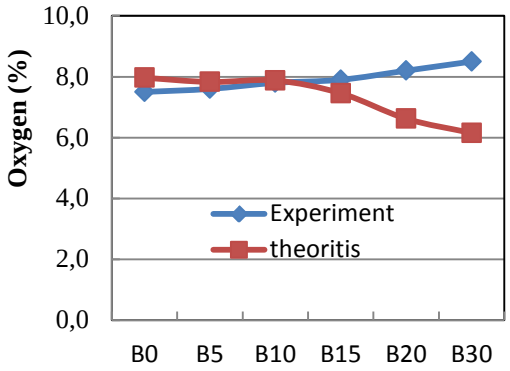


Figure 1. Influence of the ratio of fuel to excess air

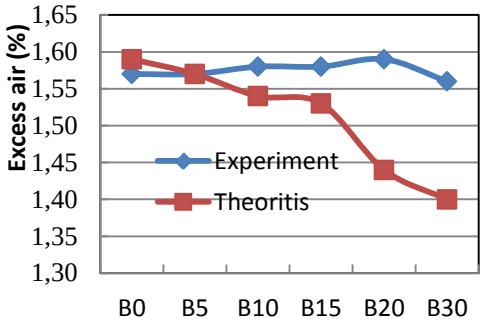


Figure 2. Variation of excess air

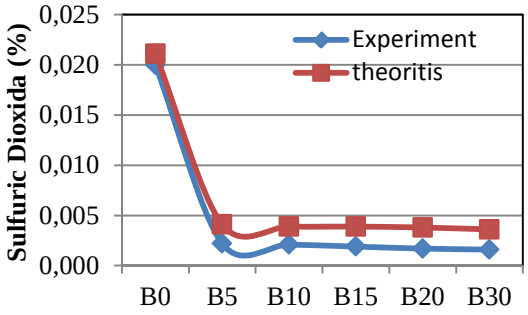


Figure 3. variation of Sulfur dioxide

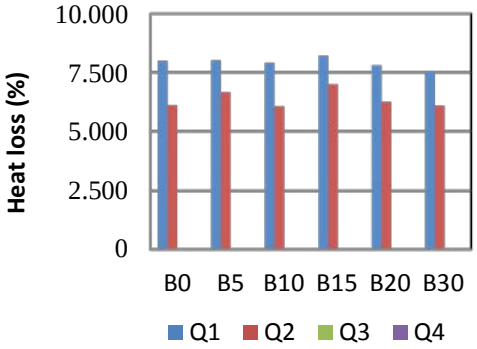


Figure 4. Heat loss

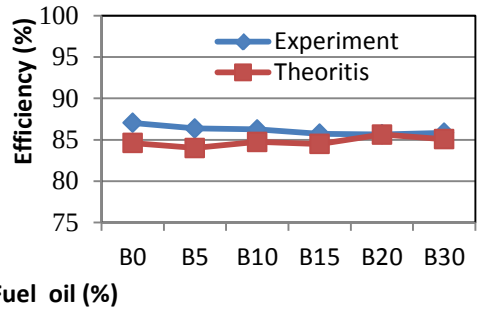


Figure 5. Efficiency of boiler

Figure 5 shows the relation of B0,B5,...,B30 to efficiency of boiler.. It shows that the efficiency obtained from experiment and calculated theoritically are practically the same. This evolution of efficiency with composition of fule seem to be constant values.

## Conclusion

From the discussions above, we can conclude as follows :

1. Efficiency boiler has highest ratios for fuel of B20 ( theoretically and experimentally).
2. The highest emissions of burning fuels produced ratio B20 ( theoritic values : $CO_2$= 10.486%, $O_2$= 6.620%, $SO_2$ = 3.92x$10^{-3}$%, $N_2$=

82.890% and experimental values : $CO_2$ = 10.7%, $O_2$= 8.2%, $SO_2$ = $1.7.10^{-3}$%, CO = 0.0565%, $NO_x$ = $2.5x10^{-4}$%.

**References**


[1] Anwar., *Analysis Technology Combustion.*, 2012.
[2] Aspandi., *Industrial Coconut*., 2012.
[3] David .M. Himmelblau., *Basic Principles and Calculation in Chemical Engineering*, Sixth Edition., 1996.
[4] Fajar et. all., *Experimental study Temperature*., 2009.
[5] Hanif., *Analyisis physic and Chemical*., 2009.
[6] Havendri., *Reduce Emissions Hydrocarbon*., 2008.
[7] Hidayat., *Consumption Fuel Oil Energy*., leaflet., 2005.
[8] Rehma., *All About Solar*., leaflet., 27 May 2012.
[9] Wirawan et. all., *Study Component Mixing Optimum.*, 2008.
Yohana et. all., *Efficiency Calculation and Conversion and Conversion from fuel oil*., 2009.