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EFFECT OF DIESEL FUEL, BIODIESEL B20 AND BIODIESEL B30 AT CAT 3406 ENGINE ON THE GREENHOUSE EMISSIONS IN PT. BUKIT ASAM TBK

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ABSTRACT— Indonesia is one of the richest countries for the renewable and nonrenewable energy resources. The energy source is needed to fulfil the household, industrial and mining needs. A coal mining process particular in PT. Bukit Asam used petroleum to run the production equipment. Cat 3406 engine which used in D8R is one of the production equipment that pushing the coal in TLS (Train Loading Station). Due to the energy source of D8R is derived from diesel, the combustion processing in the combustion chamber produces exhaust gas emissions. The emissions are too dangerous for humans, hence, to analyze the exhaust gas substance is required. In this research, collecting data of diesel, biodiesel B20 and biodiesel B30 due the engine rotation at 800 rpm and 2100 rpm at each variation is carried out. The generated gas is analyzed using measured exhaust gas emissions. As the results, B30 produced lowest emissions, while the highest torque is generated by diesel. The amount of fuel consumption for diesel and biodiesel are same.

KEYWORDS: biodiesel; gas exhaust; greenhouse emissions; engine.

1. INTRODUCTION

Indonesia is one of the richest countries for energy resource, renewable and non-renewable energy as well. The necessity of energy resource is to fulfil household, industrial and mining needs. Petroleum assigns as a first rank for national fuel consumption, i.e 48% of mixed total energy. In fact, the petroleum resource is predicted will run out within 12.26 years [5]. Furthermore, the increase of population gives significant impact on higher consumption of petroleum and the exist of greenhouse emissions as well [1]. To solve these problems, Indonesian government gives their commitment through Energy Policy on 2014, whereas the utilization of new and renewable energy will increase about 23% in 2025 and 31% in 2050 [5]. One of this alternative energy is biodiesel, which using vegetable oil as a mixture with diesel oil within varied technologies [8], [10], [11] [13], [12]. The Indonesian ministry of energy and mineral resources encourage the business world to implement the new and renewable energy, including to use biodiesel for equipment or vehicle. In case of mining area, which the site is such a long distance from town, new and renewable energy resources are a major usage to operate the heavy equipment for mining production. Therefore, it is very potential to apply the biodiesel fuel. There is not much publication on the usage of biodiesel B20 and B30. Some papers present about biodiesel B10 [2] investigated the effect of mixed of biodiesel and dexlite into the fuel consumption in Internal Combustion Engine (ICE) and the exhaust gas. [1] presented the engine performance test which using biodiesel from cooking oil. The greenhouse effect due to the vehicle activity was studied by [17] and the analysis of engine load effect to the the gas emission and fuel consumption on Cummin Qsk 45C Engine was presented by [14]. Diesel engine using biodiesel B20 and B40 from cooking oil were capable to give a good performance to use as a fuel and the result of gas emission is less than the emission of diesel fuel [3]. Some papers on greenhouse gas emissions from biodiesel have been also presented by [7], [15] to strengthen the implementation of biodiesel in industry. The engine performance based on biodiesel as a mixture for diesel was presented by [16] which showed a satisfactory result on the increase of

brake thermal and the reduction of the fuel consumption. The performance of biodiesel blends (B10 and B20) has been presented on the injection and spray characteristics [9] which showed a good result. In this research paper, the case study is taking place in PT. Bukit Asam Tbk, as the state coal mining company, which uses diesel petroleum-based to run the production equipment. For example, CAT 3406 Engine which is used in Caterpillar D8R Bulldozer to drive the coal from TLS to the train. Currently, biodiesel B30 is used as fuels in the mining heavy equipment. Therefore, this research is very suitable to analyze the performance of heavy equipment using biodiesel. The comparison of gas emission, fuel consumption and torque generation among diesel, biodiesel B20 and B30 in the CAT 3406 Engine is presented.

2. Research Methodology

This research was carried on experiment. Biodiesel B20 and B30 were investigated in the CAT 3406 engine, which is installed in the Caterpillar D8R. The specifications for both fuels and D8R Bulldozer are shown in Table 1 and Table 2, respectively.

Table 1. Characteristic of diesel specification

Parameters	Unit	Diesel	B20	B30
Cetana Numbers	-	Min 48	Min 48	Min 48
Density	kg/m ³	815 - 870	815 - 870	815 - 880
Viscosity	mm ² /s	2.0 - 4.5	2.0 - 4.5	2.0 - 5
Flash Point	°C	Min 60	Min 52	Min 52
Fog Point	°C	Max 17	Max 18	Max 18
Pour Point	°C	Max 18	Max 18	Max 18
Water Content	max ppm	500	500	425
FAME Content	% m / m	0	20	30
Sulfur content	max mg/kg	Max 0.35	Max 0.35	Max 0.25
Total Acid Number (TAN)	max mg KOH/g	0.6	0.6	0.6

Table 2. Bulldozer CAT D8R specification [4]

Description	Specification
Year	2017
Moving System	Engine CAT 3406
Power (Net) (ISO 9249/SAE J1349)	326 HP
Type blade	Type blade
Blade Capacity	10,3 m ³
Type ripper	Single
Track adjustment	Automatic hydraulic type
Service brake	Hydraulic brake
Parking brake	Wet, multiple disc
Transmission	Powershift
Pad width	610 mm
Weight	38531 kg

The procedure steps for the experiment were as follows. Preparing the CAT D8R Bulldozer with CAT 3406 engine in a secure place and ensuring the unit is ready to operate. Next, filling the fuel by varying biodiesel B20 and B30 for each procedure by turn on the engine and reposition the engine rotation at low idle or 800 rpm (without load and stepped the pedal position) for 10 minutes and then 40 minutes' usage by mining operational. Then, the reposition engine was rotated at high idle or 2100 rpm (without load and stepped max in pedals) for 10 minutes. Meanwhile, the data sampling is conducted using gas analyzer at 800 rpm and 2100 rpm. The specifications for gas analyzer are presented in Table 3. Last, observing and recording the exhaust

gas emissions, engine rpm and engine torque. The instrument and tools which are used in this research is presented in Table 4.

Table 3. Gas Analyzer specification

Description	Specification
Merk	Bacharach Fyrite Intech
Model	0024 – 8512
Measurement	Ambient temperature range -5 to 45 °C
	Flue gas temperature range -20 to 650 °C
	Oxygen range 0 to 20.9 %
	Carbon monoxide range 0 to 2000 ppm
	Combustion efficiency 0.1 to 100 %

Table 4. Measuring instrument and tools

Digital analyzer type 0024 – 8512 (Made in Bacharach Ireland)	1 ea
Thermometer digital (Made in Caterpillar America)	1 ea
Infrared thermometer (Made in Caterpillar America)	1 ea
Pressure gauge (Made in Caterpillar Amerika)	1 ea
<i>Fuel Truck</i> (Made in Japan)	1 ea
<i>Water Truck</i> (Made in Japan)	1 ea

3. Result and discussion

The combustion process in the operating unit will produce exhaust related to greenhouse emissions. Hence, the data from each type of fuel is investigated in this research to obtain the value of substances content. The data collection is carried out when the engine is rotated at 800 rpm and 2100 rpm. The other measured parameters are CO and O₂ gas, torque, and fuel consumption of each diesel, biodiesel B20 and B30.

3.1 The Comparison of Carbon monoxide (CO) at each fuel

Due to the dangerous of CO gas for human, the data collection of CO is required to figure out the quality in the combustion process. Based on Figure 1, the value of CO at 800 rpm is smaller than one at 2100 rpm because the fuel supply at 800 rpm is lower than at 2100 rpm. For diesel at 800 rpm, the lowest value of CO is 309 ppm and the highest value of CO is 311 ppm, while at 2100 rpm, the lowest value of CO is 387 ppm and the highest value of CO is 389 ppm. For biodiesel B20 at 800 rpm, the lowest value of CO is 336 ppm and the highest value of CO is 338 ppm, while at 2100 rpm, the lowest value of CO is 445 ppm and the highest value of CO is 447 ppm. The results show that biodiesel B30 gives the highest value of CO than another variant of fuel. At 800 rpm, the lowest value of CO is 435 ppm and the highest value of CO is 437 ppm, while at 2100 rpm the lowest value of CO is 497 ppm and the highest value of CO is 499 ppm.

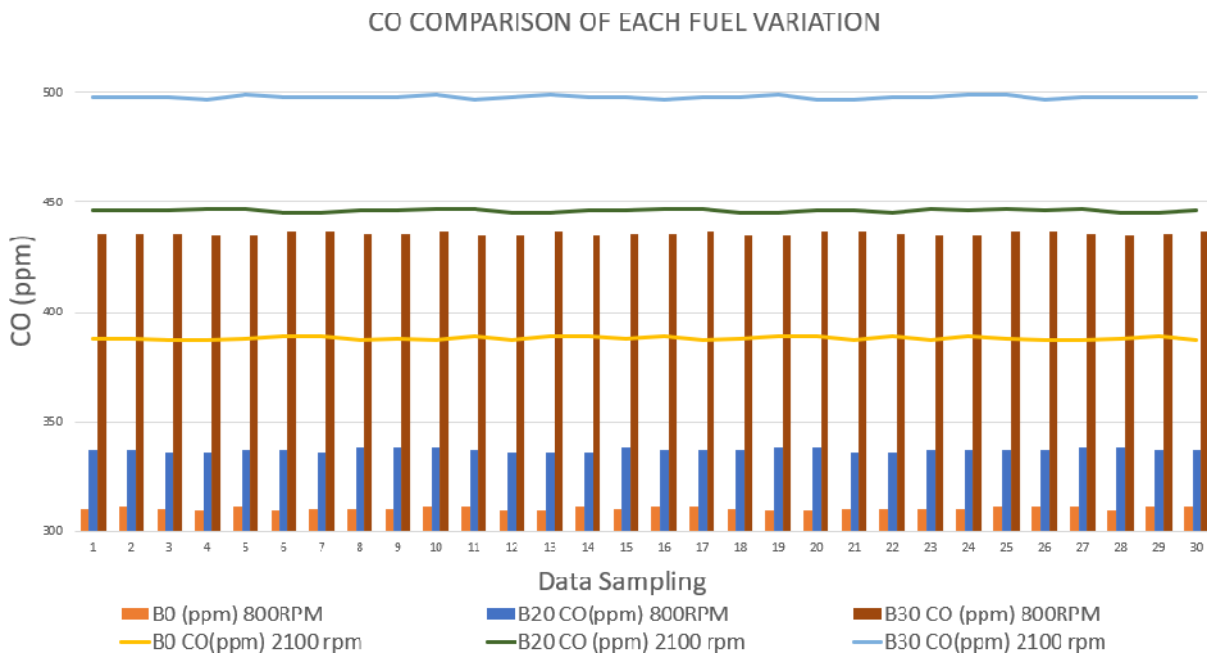


Figure 1. The CO-comparison of each fuel variation

3.2 The Oxygen Result in the Combustion Process

The combustion process needs oxygen from the air, which also to keep running the oxidizer in this process. The amount of O₂ is measured from its residue. In this research, the amount of produced O₂ from the combustion is low since the need of oxygen is high for the combustion process.

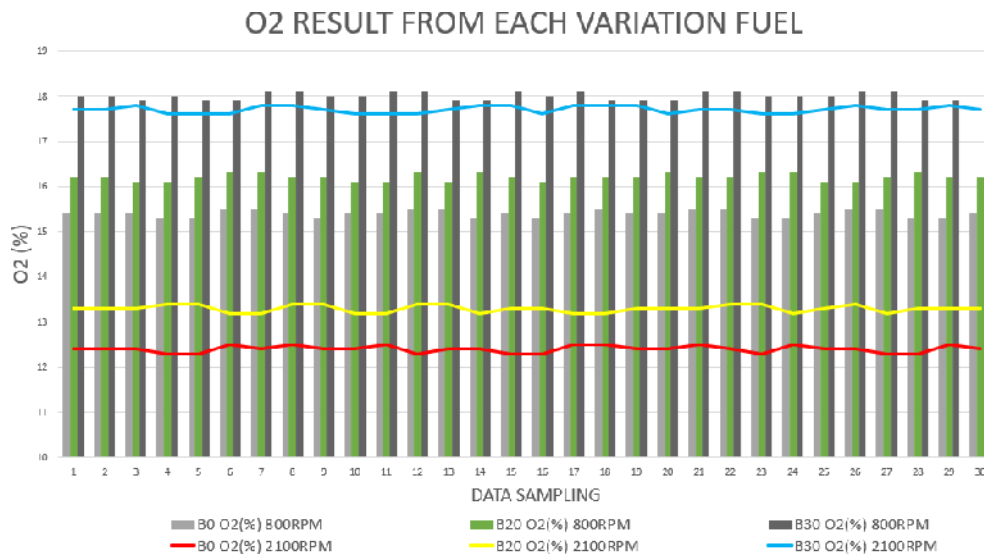


Figure 2. O₂ comparison of each fuel variation

Based on the data collection, as shown in Figure 2, the amount of O₂ resulted from diesel at 800 rpm is 15.5% for the highest value and 15.3% for the lowest value, whereas at 2100 rpm, the highest value of O₂ is 12.5% and the lowest is 12.3%. Biodiesel B20 produces 16.3% O₂ as the highest value and 16.1% as the lowest value at 800 rpm, while at 2100 rpm, it produces 13.2% for the lowest value and 13.4% for the highest value of O₂. For biodiesel B30, the amount of O₂ at 800 rpm is 18.1% for the highest value and 17.9% for the lowest value, while at 2100 rpm, the highest value of O₂ is 17.8% and the lowest value is 17.6%.

3.3 Torque Generated at Each Variation of Fuel

The value of torque which is obtained from CAT 3406 engine is vary. The results indicate that the type of usage fuel had influenced the generated torque. This difference is caused by the flash point and the engine design, which is, the flash point of diesel is the highest and more perfect than B20 and B30. As shown in Figure 3, the results at 800 rpm produced 176 ft/lb of torque for diesel, 173 ft/lb of torque for B20, and 171 ft/lb of torque for B30. At 2100 rpm, diesel produced 204 ft/lb of torque, B20 produced 201 ft/lb of torque, and B30 produced 198 ft/lb of torque.

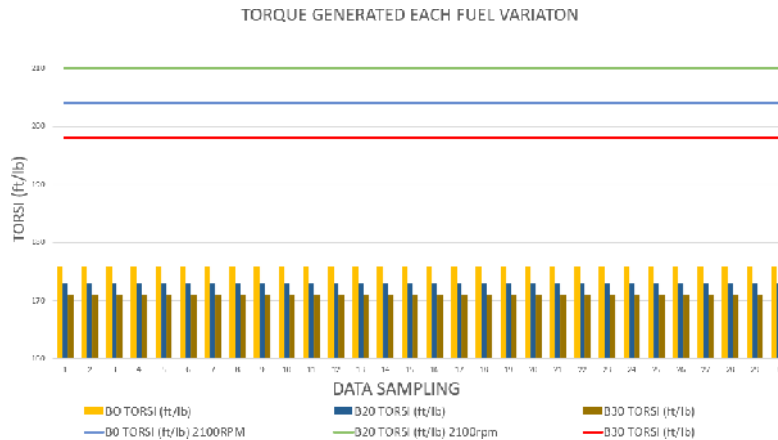


Figure 3. The generated of torque at each fuel variation

3.4 Result of CO₂ contents

In this paper, CO₂ contents were also presented since the amount of CO₂ depends on the type of fuel. The imperfect combustion might produce dangerous substances for human. Based on the data collection, diesel produced more CO₂ than B20 and B30, which is, diesel produced 0,11 tCO_{2e}/hour, B20 produced 0.09 tCO_{2e}/hour and B30 produced 0.07 tCO_{2e}/hour, respectively, as shown in Figure 4.

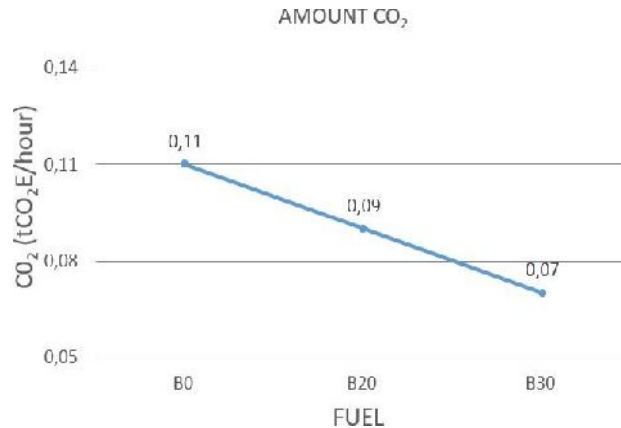


Figure 4. The amount of CO₂ hourly

3.5 Hourly Fuel Consumption

The fuel that will be used is accommodated in the fuel tank. Due to the combustion process, the fuel in the tank will reduce. The amount of hourly fuel consumption is presented in Figure 5. Based on the data collection, the fuel consumption at CAT 3406 engine is same, whereas each type of fuel needs 40 lt/hr.

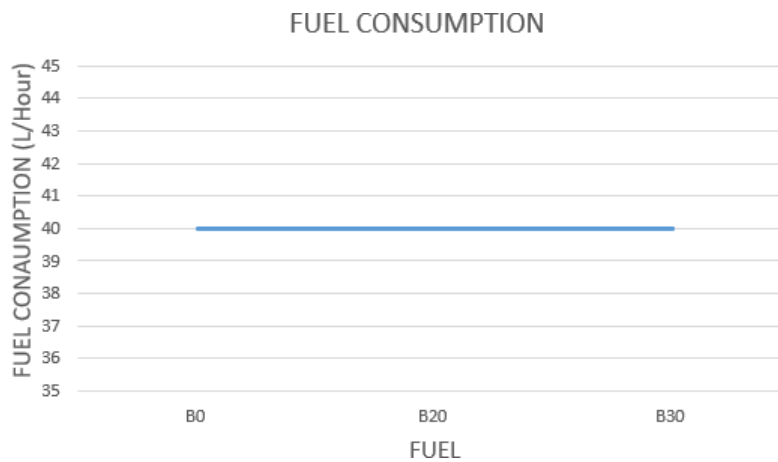


Figure 5. Hourly fuel consumption

4. Conclusion

This research paper presented the results of exhaust gas from CAT 3406 engine. Based on the investigation on the variation of fuel: diesel, Biodiesel B20 and Biodiesel B30, some conclusions were obtained as follows.

- For CO, O₂, and CO₂ concentration content, the lowest greenhouse emissions produced is at the fuel of biodiesel B30.
- There is no effect for the engine rotation with variation of diesel, biodiesel B20, and biodiesel B30.
- The highest generated torque is achieved when diesel is applied.

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