PERFOMANCE AND EXHAUST GAS EMISSION EFFECT ON A DIRECT INJECTION DIESEL ENGINE USING BIODIESEL FROM REFINED BLEACH DEODORIZED PALM OIL

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ABSTRACT

Due to the emissions from compression ignition engine (CIE) which are being placed under stricter regulations and the raise of oil price, many countries have been looking for alternative energy. Biodiesel gains recognition as a renewable fuel, which may be used as an alternative fuel to diesel fuel without any modification to the engine. Biodiesel fuels can be produced from vegetable oils or animal fats and have several advantages: they are renewable, safer, biodegradable, and they have a small or even no sulfur content and can reduce the engine exhaust gas emission.
In Indonesia, palm is the most potential plant that can be exploited to produce biodiesel. The plantation of palm in Indonesia has been grown rapidly since early 1980s. Recently, the total caltivated land of palm oil exceeds 4.9 million hectares and the palm oil production in Indonesia overcomes 10.68 million tons/year. This research was carried out at the Bandung Institute of Technology. In this study, the engine performance, exhaust gas emission, and the influence of fuel on engine componets are determined and compared with fuels: neat biodiesel fuel of Refined Bleach Deodorized Palm Oil (RBDPO), and also the blend of its and diesel fuel.
The use of biodiesel from RBDPO is found that lower emission of unburned hydrocarbon, carbon monoxide, nitrogen oxides and smoke, and that with some increase brake specific fuel consumption of the biodiesel and its blend with diesel oil. The trend and magnitude of performance and exhast gas emission is almost unchanged when the data and picture of engine component were collected and compared after the test.

1. INTRODUCTION

The use of internal combustion engine for transportation has changed the life of people than any other invention [6]. Fossil fuels, which are the main energy source of internal combustion engine, now become exhausted and their products (carbon monoxide CO, nitrogen oxides NOx, hydrocarbons HC, particulate mater PM) also cause many problems for environment and health. Besides, emission standards for them are becoming stricter and stricter, increasing challenges to the engine and fuel industry to satisfy the future legislation.

Compression ignition (CI) engines are almost used in heavy-duty trucks, ships, locomotives, construction equipments, and buses with such advantages as: high performance, low emission compared with gasoline engines. However, we know that diesel exhaust contains dozens of chemicals considered by the U.S Environment Protect Agency (EPA) to be known as hazardous air pollutants [7]. These include hydrocarbons, nitrogen oxides, fine particulate matters, carbon monoxides, and toxic air contaminants.
Together with the increasing emission standards for CI engines and covering environment and energy efficiency, there are two majors that need addressing: fuel

economics and pollutants emission. Research has focused not only on new engine technologies and after-treatments, but also on modifying diesel fuel (alternative fuels). Using of biodiesel to produce cleaner burning diesel fuel has been recognized as a way to comply with new stringent emission levels [8]. A small amount of molecular oxygen (11%) in biodiesel has shown to reduce particulate matter [9-11].

Asian countries have limited resources of liquid fossil fuels, but they have potential in alternative fuels (natural gas, biomass and coal…). In Indonesia, palm is the most potential plant that can be exploited to produce biodiesel. The plantation of palm in Indonesia has been grown rapidly since early 1980s. Recently, the total caltivated land of palm oil exceeds 4.9 million hectares and the palm oil production in Indonesia overcomes 10.68 million tons/year [2]. Funded by AUN/SEED-Net, this research has been conducting at the Bandung Institute of Technology. The purposes of this study were to compare the performance, the exhaust gas emission and the influence of the fuels on components of a direct CI engine when it was used with biodiesel from RBDPO and its blends with petrodiesel fuel (conventional diesel fuel).

2. EXPERIMENTAL EQUIPMENTS AND PROCEDURES

2.1 Test Engine and Operating Condition.

These experiments were conducted on a single cylinder engine. This is a direct injection engine with horizontal type, four-stoke cycles, naturally aspirated and water cooled. The engine was connected to a 5 kW, 220V, 22.7A, 50 Hz electric generator. The electric generator was supply to series heaters to vary engine loads. The specifications of the engine are listed in table 1.

Table 1: Engine specification

Engine Name	ZS195B2-DI
Engine Type	Direct Injection
Bore (mm) x Stroke (mm)	95 x 115
Cubic Capacity (cc)	815
Compression Ratio	20 : 1
Maximum Power (HP/rpm)	14 / 2000
Rated Power	12 / 2000
No of Cylinder	1
Fuel Injection Pump	Bosch in line
Fuel Injector Type	Bosch multi-hole
Aspiration	Natural

The tests were carried out following SAE Technical Series 942010 'Diesel Fuel Detergent Additive Performance and Assessment' [1]. All the components of the engine, which were possible influenced by the fuel using before (plunger of injection pump, injector) and after combustion process (piston and piston rings), were changed with new parts. Before the test was started, the "break-in" process was done in one hour by using new piston and piston rings and all old components to break in to piston and piston rings. The performance and exhaust gas emission also were measured after break-in process and after finishing the main seventeen-hour endurance test. Weight, dimension, and photograph of engine components were collected before and after the test [3-5].

2.2 Test fuels.

There were three types of fuels used in this study. They are B100 (100% biodiesel fuel from RBDPO), B10 (blend in volume ratio between 10% biodiesel from RBDPO and 90% petrodiesel) and petrodiesel fuel. The biodiesel fuel from RBDPO was prepared by the circulated-mix tank reactor in Laboratory of Thermofluid and Utility System at The Bandung Institute of Technology [3-5]. The fuel properties are described in table 2.

Table 2: Fuel properties

Parameter	**B00**	**B10**	**B100**
Specific gravity at 40 ^oC, mg/ml	0,83	0,84	0,863
Kinematic viscosity at 40^{o}C,	5,16	5,09	4,44
Low heating value (kJ/kg)	4204	4166	3788
Cetane index	42,0	-	62.1
Acid value, mg-KOH/g	-	-	0,064
Free glycerol %-b	-	-	0,007
Total glycerol, %-b	-	-	0,17
Ester content, %-b	-	-	99,58

3. RESULT AND DISCUSSION

3.1 Brake Specific Fuel Consumption (Be).

The brake specific fuel consumption or the inversion of thermal efficiency for three types of fuel before and after the test is shown in Figure 1. From the figure, the trend and magnitude of brake specific fuel consumption of the engine after the test is nearly the same as that before endurance test. Be for B100 is higher than B10 and B00 because of the lower energy content of biodiesel (table 2).

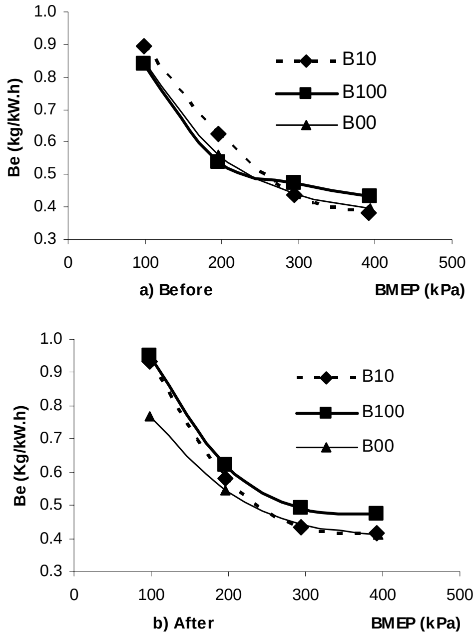
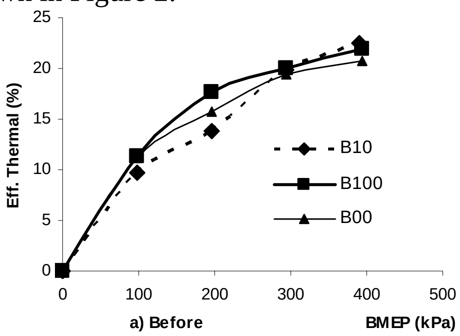


Fig.1: Brake Specific consumption before (a) and after (b) the test

3.2 Thermo Efficiency *(η_e)*.

Thermo efficiency is the inversion of brake specific fuel consumption. The trend and magnitude of thermo efficiency have the same reason as the previous explanation and they are shown in Figure 2.



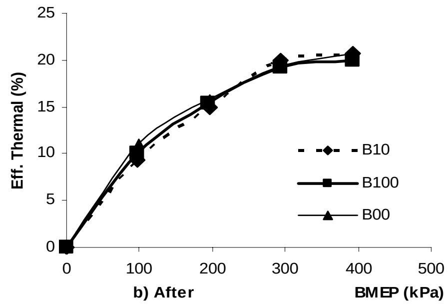


Fig.2: Thermo efficiency before (a) and after (b) the test.

3.3 Carbon Monoxide Exhaust Gas Emission (CO).

Biodiesel has significantly lower of CO exhaust gas emission than petrodiesel fuel. This was likely due to the oxygen content of the B100 fuel. The trend and magnitude of CO were unchanged after the test and were shown in Figure 3.

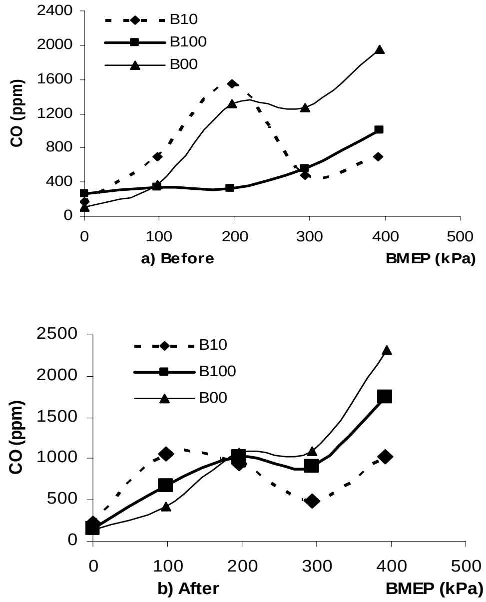
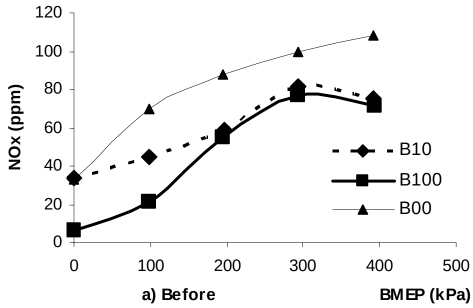


Fig.3: Carbon monoxide exhaust gas emission before (a) and after (b) the test.

3.4 Nitrogen Oxide Exhaust Gas Emission (NOx).

The trend and magnitude of NOx exhaust gas emission were almost unchanged. The higher percentage of biodiesel content, the lower of NOx exhaust gas emission. This can explain because of biodiesel cetane index higher than petrodiesel (table 2). Higher centane index gives lower premixed combustion process. The lower premixed combustion process will decrease low combustion temperature thus the NOx formation will reduce. Figure 4 showed the NOx exhaust gas emission.



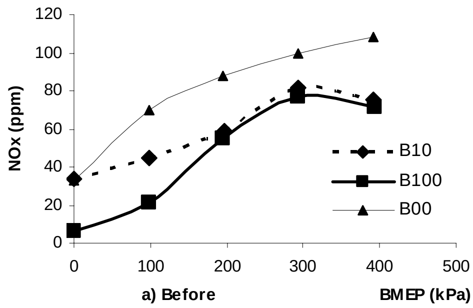
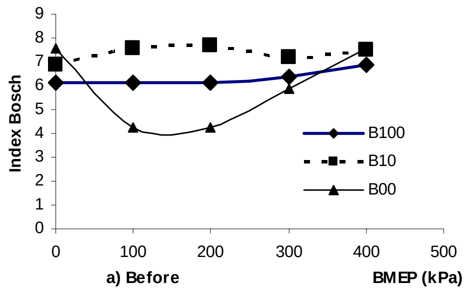


Fig.4: Nitrogen oxide exhaust gas emission before (a) and after (b) the test.

3.5 Smoke Exhaust Gas Emission.

The smoke in exhaust gas emission, which is shown in Figure 5, is represented by Bosch Index has the same trend as CO exhaust gas emission



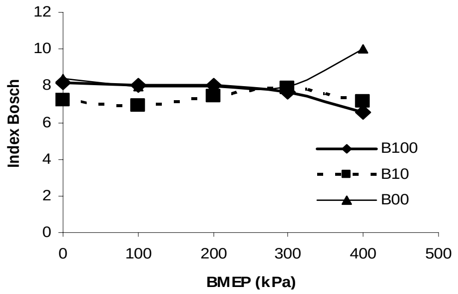
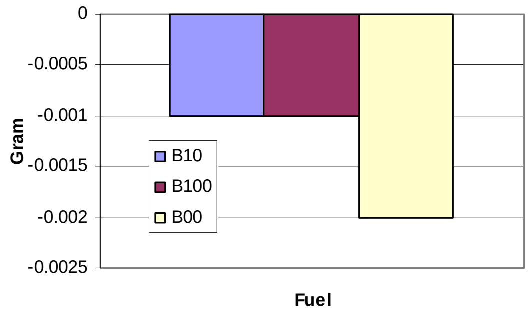


Fig.5: Smoke exhaust gas emission before (a) and after (b) the test.

3.6 The Effect on Engine Components

3.6.1 Plunger

The effect of the fuel on plunger is shown in Figure 6. The decrease in weight of the plunger using biodiesel is less than that of petrodiesel because biodiesel has higher lubricity than petrodiesel.



B100 B10 B00

Fig.6: The change in weight and photographs of plunger after the test.

3.6.2 Plunger House

In the plunger house, the weight of B10 and B00 increased. The increase in weight was considered by the accumulation of deposit. Figure 7 shows the change in weight of plunger house. From the visual observation, it was very difficulty to separate the difference effect between three types of the fuels.

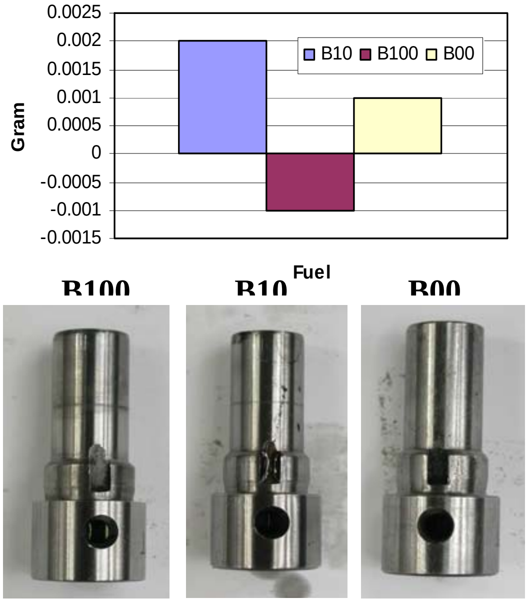


Fig.7: The change in weight and photographs of plunger house after the test.

3.6.3 Nozzle

Figure 8 shows the increase in weight of nozzle. The highest weight increasing is B00 and following B10 and B100. This can explain from previous because of oxygen content in biodiesel fuel higher than petrodiesel. The good combustion process gives reducing deposit formation in combustion chamber.

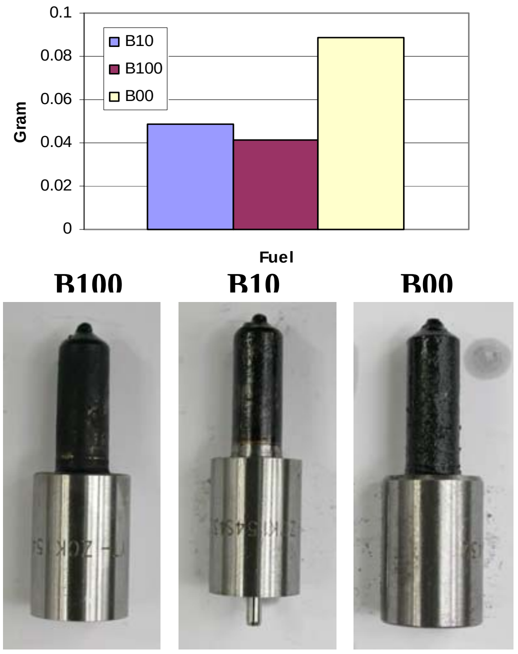


Fig.8: The change in weight and photographs of nozzle after the test.

3.6.4 Piston

The increase in weight of piston is the same as that of nozzle. The higher Biodiesel content in the fuel, the lower increase in weight. Figure 9 shows the change in weight and photographs of piston after the test. As previous explanation, the increasing of the weight is the deposit accumulated on piston crown. Because diesel engine is inhomogeneous engine, some parts of mixture have not enough air to oxidize fuel and will be become carbon deposit in combustion chamber. In this case, biodiesel has 11% of oxygen thus it gives a better combustion process and reduces the deposit in combustion chamber. In the visualization, the lower biodiesel content, the darker color of deposit.

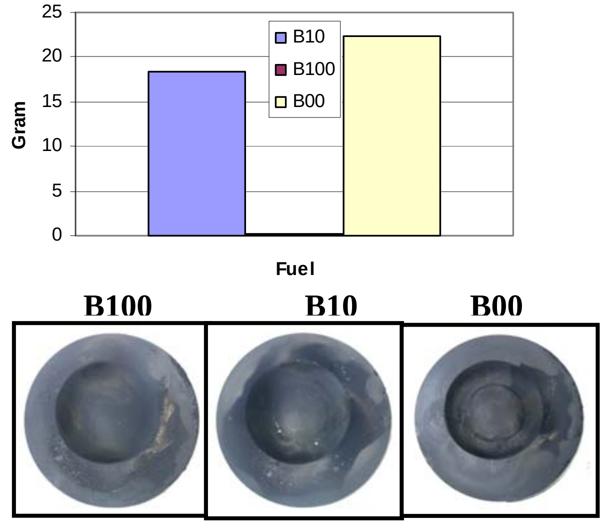
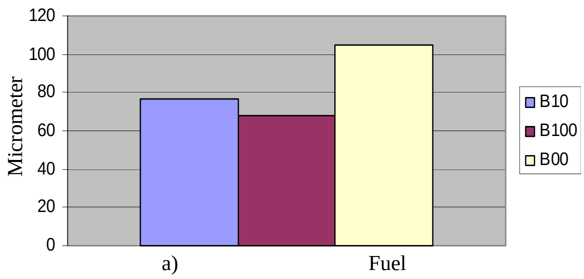
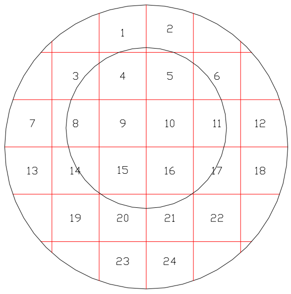


Fig.9: The change in weight and photographs of piston after the test.

The deposit thickness of piston crown shows in figure 10(a) the same trend as the changed of weight and the same result of the visualization on the piston crown. The average thickness is measured at 24 points in the piston crown show in Figure 10(b).



a)



b)

Fig.10: The average thickness and the position of thickness measurement in piston.

3.6.5 Cylinder head

In cylinder head, the trend and the average deposit thickness are the same as nozzle and piston crown because they are parts of the combustion chamber. Figure 11 shows the average thickness and the photographs of the cylinder head after the test.

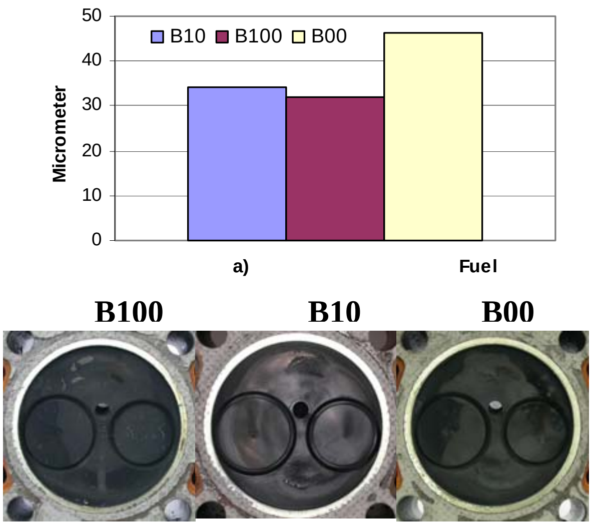


Fig.11: The change in weight and photographs of cylinderhead after the test.

4. CONCLUSION

Based on the data collected during this research, several conclusions may be reached regarded the effect of biodiesel on diesel exhaust gas emissions.

Biodiesel was associated with lower emissions CO, NOx, and smoke compared to levels associated with diesel fuel. The lower emission levels were likely due to the fact that biodiesel contain about 11% oxygen by weight, and this oxygen helps to oxidize these combustion products in the cylinder

The deposit in combustion system of diesel engine run with biodiesel and its blends with petrodiesel fuel is slightly lower than that of petrodiesel fuel.

5. ADKNOWLEDGEMENT

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