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Effect of Dissolving Ozone in Biodiesel Fuel on Diesel Engine Performance

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Abstract The use of biodiesel fuel still has problems. One of the problems is that it is not easy to ignite this, which causes incomplete combustion, which causes the performance of the diesel engine to be less than optimal. This study aims to solve the problem of biodiesel properties affecting the performance of diesel engines. To overcome this problem, ozone is dissolved in diesel fuel because the oxidizing ability of ozone contains more chemical potential energy than oxygen, it can result in significantly greater product pressure and heat during combustion. In this study, ozone dissolution can be carried out using an ozone generator which is a simple, and environmentally friendly technology, ozone dissolution into 30% biodiesel fuel was carried out with variations in ozone dissolution, namely 140×10^{-6} g/s, 278×10^{-6} g/s, 556×10^{-6} g/s. The performance measurements produced by the engine were analyzed using the Diesel TV-1 engine with a compression ratio of 1:18 and at 1 kg, 3 kg, 5 kg, 7 kg, and 9 kg loadings. The results showed that dissolving ozone in the fuel increased the torque produced by the engine at a load of 9 kg B30% by 16.45 Nm, B30% higher with ozone dissolving 556×10^{-6} g/s by 16.81 Nm, increasing the effective power at a load of 9 kg B30% by 2.49 kW higher B30% by dissolving ozone 556×10^{-6} g/s by 2.56 kW, reducing specific fuel consumption at a load of 9 kg B30% by 0.33 kg/kW.h lower B30 % with ozone dissolving 278×10^{-6} g/s of 0.30 kg/kW.h, increase the volumetric efficiency of 9 kg load B30% by 0.066% higher than B30% by dissolving ozone 556×10^{-6} g/s by 0.070%. Dissolving ozone in biodiesel fuel can increase engine torque by 2.18%, increase effective power by 2.8%, reduce specific fuel consumption by 13.33% and increase volumetric efficiency by 14.04%.

INTRODUCTION

The diesel motor is one type of engine that is used to meet large power requirements, especially in the field of transportation and stationary propulsion. Currently, the growth of motorized vehicles in Indonesia, the growth of passenger cars is around 6% per year [1]. Based on data from the Central Statistics Agency in 2018, the number of motorized vehicles by type, namely passenger cars reached 14,830,698 units, buses reached 222,872. units and goods cars reached 4,797,254 units[1]. The three types of vehicles mentioned above generally use diesel engines. In addition, the use of diesel engines is also widely applied in several fields such as agriculture and industry.

The rapidly growing use of diesel engines is accompanied by an increase in the use of diesel fuel produced from petroleum. Based on this, the world's total primary energy supply increased by 62.91% from 1990 to 2018 to become 14281.89 Mtoe (Million tonnes of oil equivalent) [2]. Meanwhile, oil production in Indonesia tends to decline in the past decade. Based on data from Indonesia's 2019 Energy Outlook, shows that oil production in 2009 was 346 million barrels (949 thousand BPD) and was around 283 million barrels (778 thousand BPD) in 2018[3]. Another impact of the use of petroleum is emissions. Total CO2 emissions in the world increased by 63.35% from 1990 to 2018 33513.25 Mt (Metric tons)[3].

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Efforts have been made to reduce the consumption of petroleum and exhaust emissions in diesel engines is the use of Biodiesel in diesel fuel. The mandatory biofuel (BBN) program has been implemented by the Indonesian government since 1 January 2020 through biodiesel fuel with 30% biodiesel in diesel fuel (B30)[4].

The use of biodiesel fuel still has problems, the performance of these vegetable oils is that they are not easily ignited in cold conditions (poor cold-starting performance) and there is a tendency for gum formation [5]. The characteristics of biodiesel, namely the value of density, viscosity, and acidity are higher than diesel fuel [5][6]. Several research results on the use of biodiesel in engines have been carried out to overcome problems in biodiesel. Viscosity is an important biodiesel parameter, according to specifications and impact on fuel quality, High viscosities will tend to form larger droplets during injection, resulting in poorer atomization [7].

Efforts to reduce the viscosity have been carried out by adding methyl linoleate and heating at a temperature of 1000 to 1700 C, 1580 C less than 50 C, adding methyl linoleate as a pro-oxidant and increasing the rate of squalane autoxidation and changes in viscosity, [8]. Mixing ULSD (Ultra-low sulfur diesel) and Biodiesel can improve combustion quality and thermal efficiency. The results of this study indicate that the power, torque, and exhaust gas temperature decrease by about 9%, 2%, and 4% respectively with the addition of biodiesel, on the other hand, the addition of biodiesel in the mixture increases the specific fuel consumption and braking thermal efficiency by about 6%. and 11% [9].

The ozonation reaction also means that there is a reaction to break double bonds, especially single double bonds, which in the end will produce compounds with simpler carbon chains than the original compounds. The hydrocarbon compounds formed are expected to also improve the characteristics of these esters when used as fuel or as fuel additives for diesel engines. The addition of ozone to the engine combustion process has also been carried out to control emissions, increase ignition, fire propagation, and improve fire stabilization [10].

MATERIALS AND METHODS

Fuel Mixture

The fuel used in this research is biodiesel 30%, biodiesel 30% with ozone dissolving 140×10^{-6} g/s, 30% biodiesel with ozone dissolving 278×10^{-6} g/s, 30% biodiesel with ozone dissolving 556×10^{-6} g/s. 30% biodiesel and ozone are mixed in a container by dissolving ozone into 30% biodiesel fuel using an ozone generator by varying the amount of ozone mixed.

Methodology

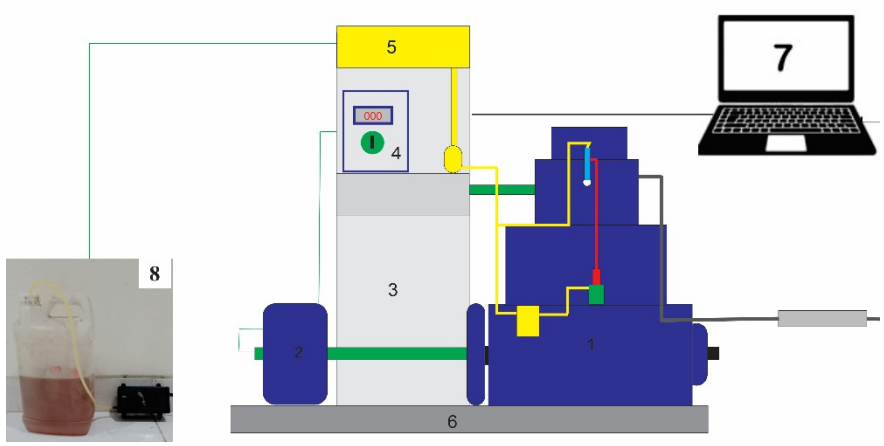

FIGURE 1. Research Scheme

Before researching the desired conditions, the machine is operated in no-load conditions for 4-5 minutes. The operating conditions are achieved gradually by giving the machine loads of 1 kg, 3 kg, 5 kg, 7 kg, and 9 kg. Data recording is done after the machine reaches a stable condition at each loading.

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Measurement of engine performance is carried out using a test dynamo which is directly connected to the engine, reading and recording of test results data are carried out using the IC-Engine application. Parameters measured are torque, effective power, specific fuel consumption, volumetric efficiency.

Engine Set Up

The engine used in this research is a TV1 model diesel engine (vertical 1 cylinder type). The diesel engine has a power of 3.50 kW with a constant rotation of 1500 rpm. It has 1 cylinder, four-stroke, water-cooled, cylinder diameter 87.50 mm, stroke length 110.00 mm, connecting rood length 234.00 mm, compression ratio 1 to 18, cylinder volume 661.45 cc (Table 1).

TABLE 1. Engine Specification

Engine Model	**Kirloskar TV1**
Number of Cylinders	1
Fuel	Diesel
House power	3.5 kW
Cylinder Diameter	88.5 mm
Stroke length	110 mm
connecting rood length	234 mm
cylinder volume	661.45 cc
Compression ratio	12 to 18: 1

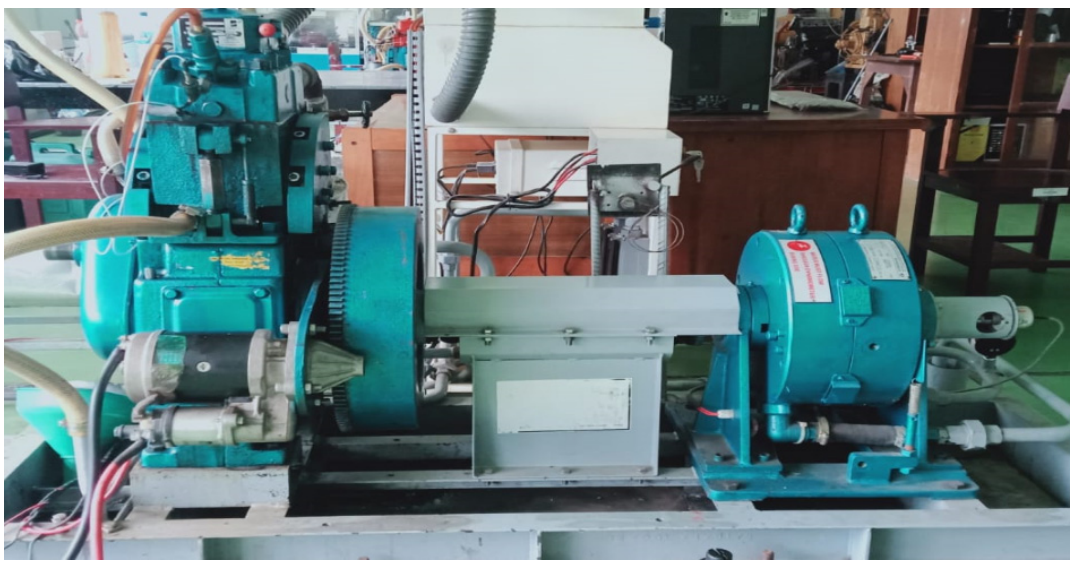

FIGURE 2 Engine Set Up

RESULTS AND DISCUSSION

Torque

Torque is the ability of a machine to do work. Fig. 3 shows the torque generated by the engine using ozone dissolving in B30% fuel has increased compared to the torque generated by the engine using B30% fuel. The greatest increase in torque produced by the engine at 556×10^{-6} g/s 9 ozone dissolving load of 16.81 Nm was 2.1% greater than using B30% without ozone dissolving. This is because B30% fuel dissolved in ozone has a low flash point so that it affects combustion, the fuel is easier to ignite (ignition delay). Delayed combustion is a parameter that is very influential on the beginning to the end of the combustion process in the engine combustion cylinder. In the combustion process, the shorter the delay of combustion, the better the ignition quality.

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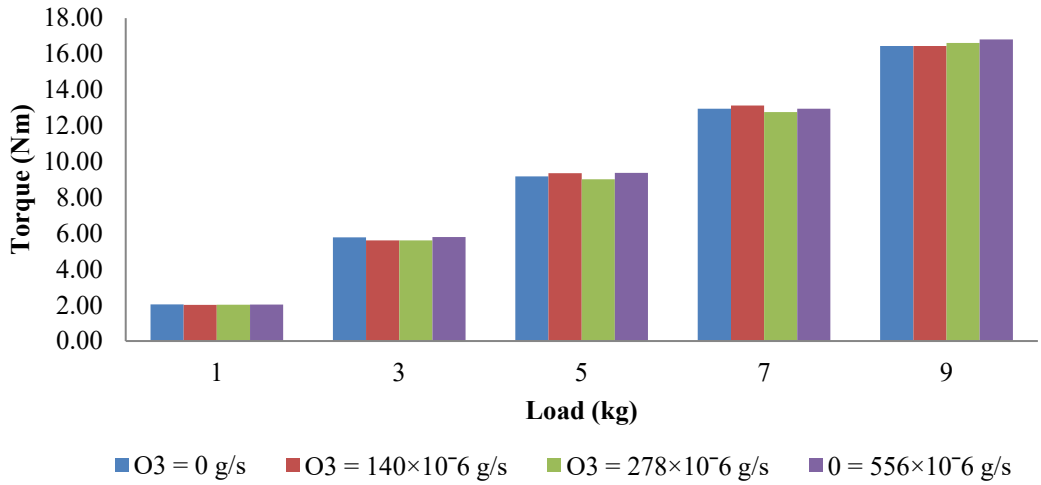

FIGURE 3. Engine Torque

Brake Power (BP)

Shaft power is the effective power on the shaft that will be used to lift the engine load. The effective power is defined as the torque moment multiplied by the crankshaft rotational speed. Fig. 4 shows the effective power produced by the engine using ozone dissolving in B30% fuel has increased compared to the effective power produced by the engine using B30% fuel. The effective power generated by the machine using B30% without ozone dissolving is 2.49 kW The largest increase in effective power produced by the machine is at 556×10^{-6} g/s ozone dissolving and at a load of 9 kg, which is 2.56 kW, the percentage increase is 2.81% taller. The increase in effective power is due to the torque generated by the engine using 30% biodiesel fuel with ozone dissolving higher than biodiesel fuel without ozone dissolving.

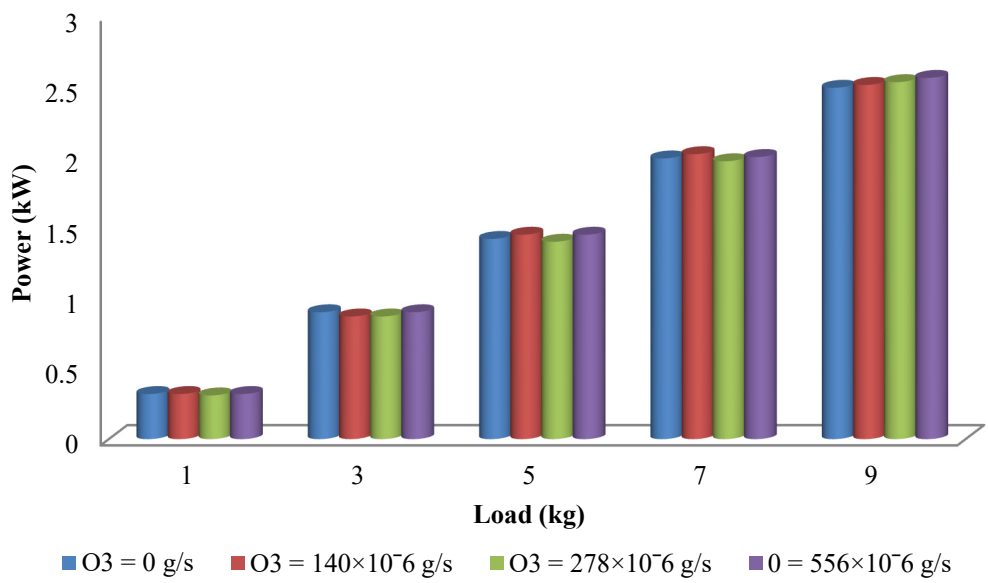

FIGURE 4 Engine Effective Power

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Specific Fuel Consumption (SFC)

This specific fuel consumption is an indicator of the effectiveness of a combustion engine in the use or consumption of fuel consumption to produce motor power. The smaller the specific fuel consumption value, it can be said that the fuel motor is more efficient in fuel consumption. Fig. 5 shows that the lowest specific fuel consumption is in ozone dissolving278×10^{-6} g/s which is equal to 0.30 kg/kWh. This is because the effective power produced by the engine uses 30% biodiesel fuel with increased ozone dissolution and lower fuel consumption compared to using 30% biodiesel fuel without ozone dissolving.

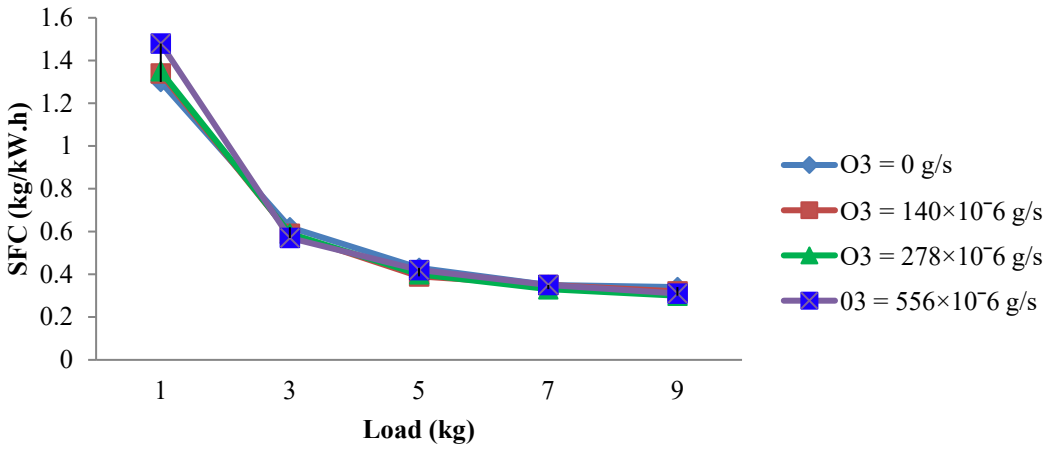

FIGURE 5. Engine specific Fuel Consumption

Volumetric Efficiency

Volumetric efficiency is the ability of a machine to do work efficiently. Fig.6 shows the volumetric efficiency produced by the engine with ozone dissolving in B30% fuel has increased compared to the volumetric efficiency produced by the engine using B30% fuel. The largest increase in volumetric efficiency produced by the machine at 556×10^{-6} g/s ozone dissolving an average of 10.71% greater than using B30% without ozone dissolving at each loading. This is because the dissolution of ozone into biodiesel fuel 30% increases the calorific value of the fuel. The calorific value shows the heat energy contained in each unit mass of fuel. The higher the calorific value of a fuel, the greater the energy contained in the fuel per unit mass.

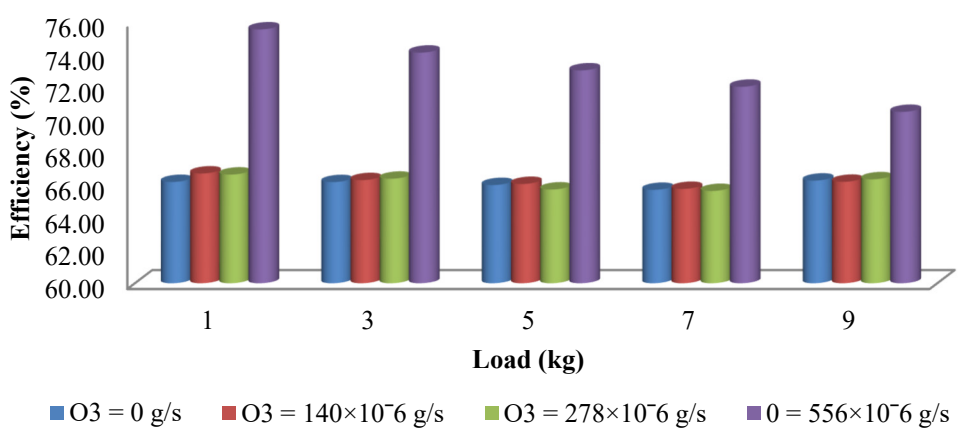

FIGURE 6. Engine Volumetric Efficiency

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CONCLUSION

The results of testing the effect of dissolving ozone in biodiesel fuel on diesel engine performance can be concluded as follows. The torque produced by the engine increases the most, namely at 556×10^{-6} g/s ozone dissolution, namely at a load of 9 kg of 16.81 Nm, an increase of 2.1% compared to using B30% fuel. The highest effective power produced by the engine is at 556×10^{-6} g/s ozone dissolution, which is at a load of 9 kg at 2.56 kW, 2.8% higher than using B30% fuel. The specific fuel consumption consumed by the engine is the lowest at 278×10^{-6} g/s ozone, which is 0.30 kg/kW.h, 13.33% lower than B30% fuel at a load of 9 kg. The biggest increase in volumetric efficiency produced by the machine at 556×10^{-6} g/s ozone dissolving an average of 14.04% greater than using B30% without ozone dissolving at each loading.

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