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To cite this article: Johan Firmansyah *et al* 2019 *J. Phys.: Conf. Ser.* **1373** 012010

Effect of Water Content in Methanol on The Performance and Exhaust Emissions of Direct Injection Diesel Engines Fueled by Diesel Fuel and Jatropha Oil Blends with EGR System

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Abstract. Diesel engines are usually used because of their durability and high efficiency. Therefore the number of diesel engine uses is increasing. This results in an increase in the amount of diesel fuel consumption and air pollution from diesel engine exhaust gases, especially soot emissions. To reduce this soot emission, methanol which is rich in oxygen is added to diesel. The substitution of alcohol into diesel has an impact on the performance of the diesel engine. Therefore, this study is focused on investigating the effect of water content in methanol on diesel engine performance and soot emissions. The study was conducted using an Isuzu 4JB1 diesel engine equipped with a cold EGR system. The ratio of the diesel-jatropha-methanol mixture used is 55/30/15% on a volume basis. While the water content in methanol used is 0 to 25% at a 5% interval. The test is carried out at a stationary 2500 rpm and given a load of 25% to 100% at a 25% interval. A dynamite Land & Sea dynamometer and stages 898 smoke meter were used to measure performance and soot emissions. The experimental data shows that the higher water content in methanol in the mixture of diesel-jatropha-methanol fuel causes a reduction in performance and an increase in soot emissions of diesel engines

1. Introduction

Diesel engines are usually used in the industrial automotive because they have greater power and higher fuel efficiency than gasoline engines. However, diesel engines produce higher NOx and soot emissions and are harmful to human health. Therefore, the widespread use of diesel engines results in air pollution due to increased exhaust emissions and increased demand for diesel fuel. Jatropha is one of the alternative non-food alternative fuel sources that has been studied both as pure fuel and as a mixture of diesel fuel so that it is expected to reduce dependence on fossil fuels [1]. However, the use of jatropha as a mixture produces higher soot emissions than diesel [2]. In addition, the addition of jatropha as a mixture of fuel produces a decrease in torque and power compared to pure diesel. This is due to the low calorific value in Europe [3].

Methanol is an alcohol group that can be considered to reduce smoke emissions and increase fuel demand when used as additives in diesel fuel [4]. High oxygen content in methanol is a major factor in reducing the emission of smoke produced by diesel engines [5]. Syaiful et al., 2017 [6] in their study observed that adding methanol to a mixture of jatropha and diesel fuels was able to reduce soot emissions. This decrease increases with the increase in the percentage of methanol in the fuel mixture. In addition, the greater the methanol content in diesel mixture fuel results in a decrease in torque and greater power [7]. A decrease. In this study Low Purity Methanol (LPM) is used as a substitute for methanol because in addition to its price is cheaper, LPM has a higher H_2O level so that it will reduce soot emissions caused by diesel engines.

A diesel engines due to the high temperature in the combustion engine [8]. Exhaust Gas Recirculation (EGR) is an effective pressure and inexpensive method for reducing NOx emissions by recirculating some of the exhaust emissions gas into the combustion engine [9]. A decrease concentration of air in the combustion engine causes a decrease in combustion temperature so that NOx emissions also decrease. The high NOx emissions in diesel engines can be decreased by using EGR system because EGR can reduce the concentration of air in the combustion engine so that the temperature in the combustion chamber decreases. EGR system used in the study is Cold EGR type. Some of the exhaust emissions is circulated into the combustion engine via a heat exchanger while the Hot EGR type is without using heat exchanger media.

2. Methodology

Based on the above, the study observed the effect of methanol with varying moisture content on soot emissions and performance produced by direct injection fuel diesel fueled and European-style system.

Research Methods

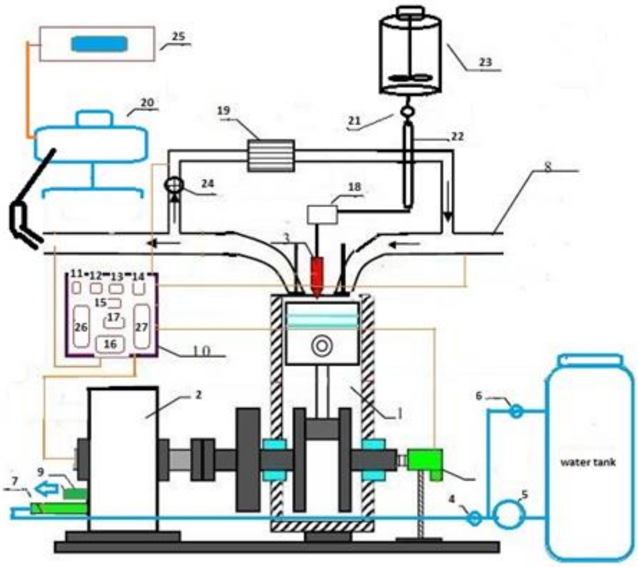


FIGURE 1. Experimental equipment scheme

A fuel used in this study is diesel, jatropha, and methanol with various different water content. Diesel fuel is produced by PT. Pertamina Tbk. The variation of fuel mixture in this study is 100% diesel (D100), 70% diesel and 30% jatropha (DJ30), 55% diesel, 30% jatropha and 15% methanol with a water content of 5%, 10%, 15%, 20 %, and 25% (DJ30M15A5, DJ30M15A10, DJ30M15A15, DJ30M15A20, DJ30M15A25).

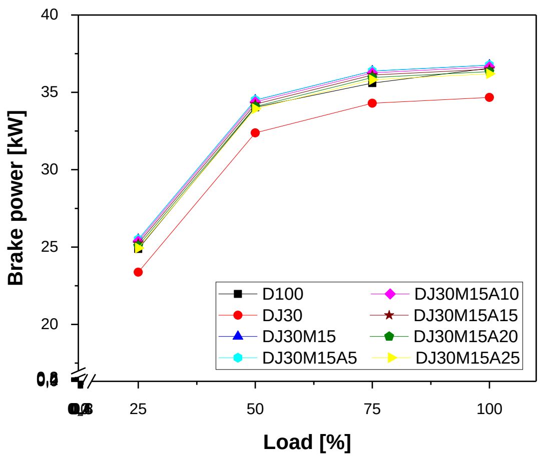
3. Result and Discussion

Isuzu 4JB1 diesel engine is connected by a dynamometer. Engine rotation is measured using a digital tachometer with the proximity sensor. A measuring cup and stopwatch are used to measure the fuel flow rate. Exhaust gas temperature was measured using a digital thermometer, while the air flow rate and EGR flow rate were obtained by measuring the difference in pressure on the orifice. The experimental equipment scheme can be seen in Figure 1. Tests are carried out at a constant engine speed of 2500 rpm. In this condition, the EGR input is cooled by giving the cooler to the EGR channel to be inserted into the cylinder (Cold EGR). Variation in valve openings starting at 25%, 50%, 75%, and 100% is carried out for each variation of the EGR valve opening. The variations above are carried out for each mixture of fuel. The fuel specifications are shown in Table 2.

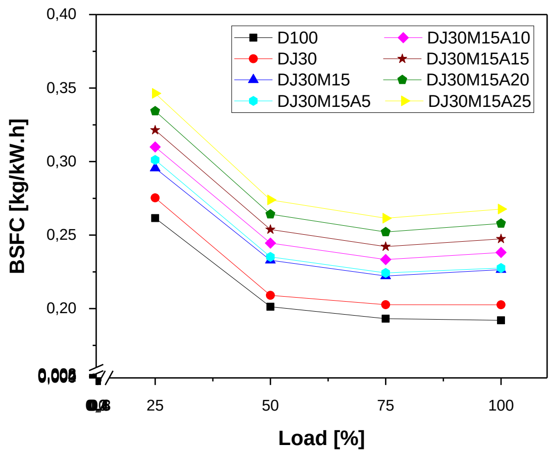
TABLE 1. Fuel properties comparison of methanol, jatropha and diesel fuel

No	Properties	Diesel	*Jatropha*	Methanol
1	Cetane number	48	41.8	4.8
2	Water Content (%v)	0.05	3.16	0.05
3	Viscosity (mPa.s)	2.0-5.0	3.23	0.6
4	Calorific Value (MJ/kg)	45.21	37.97	22.08
5	Flash Points (°C)	60	198	13
6	Oxygen content (%)	-	10.9	34.8

RESULT AND DISCUSSION



(a)



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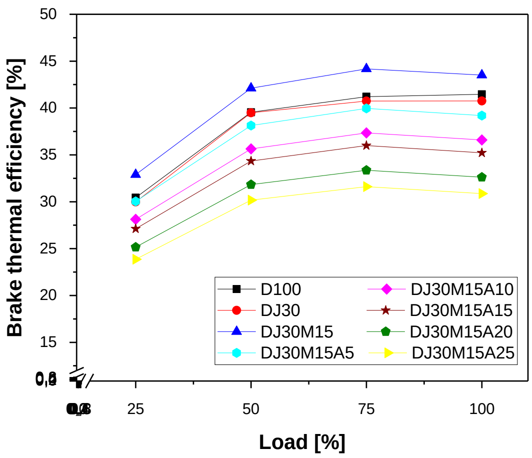
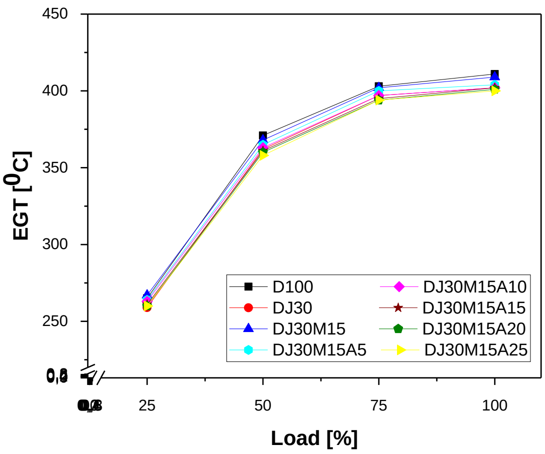
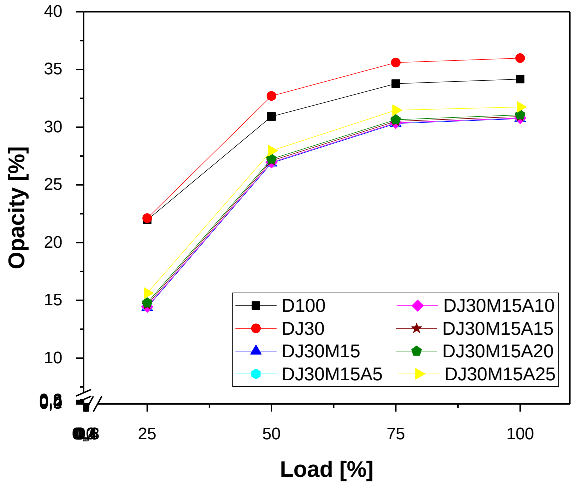


(c)



(d)



(e)

FIGURE 2. (a) The brake power characteristics, (b) Brake-Specific Fuel Consumption, (c) Brake Thermal Efficiency, (d) Exhaust Gas Temperature, and (e) Exhaust Gas Oppacity Performance of direct injection fuel diesel engines by EGR cold systems using various diesel fuel, jatropha, and methanol compositions.

Figure 2.(a) shows the value of Brake Power increases with increasing load. The use of diesel-jatropha-methanol mixed fuel show results in a slight increase in the value of brake power. The high oxygen content and low viscosity in methanol facilitate the process of injecting fuel [5] thus causing the burning rate to increase [10]. The highest increase in brake power value occurs in DJ30M15 fuel which is 2.53% compared to D100.

Figure 2.(b) shows a reduction in the value of the Fuel Consumption (BSFC) Specific Brake with increasing load. The use of diesel-jatropha-methanol mixture produces a higher BSFC value than D100. This is due to the low calorific value in Europe and methanol in diesel-jatropha-methanol mixed fuels [11]. The highest increase in BSFC value occurs in DJ30M15A25 fuel which is equal to 39.42% compared to D100 at 100% loading.

Figure 2.(c) presents a reduce in Brake Thermal Efficiency (BTE) when using a blended of diesel-jatropha-methanol fuel. This is due to lower calorific value than pure diesel. In addition, high viscosity in Europe also causes BTE to tend to decrease [12], [13]. The highest decrease in BTE value occurred in DJ30M15A25 fuel which was equal to 25.3% at 100% loading.

Figure 2.(d) show the result is a graph of the Exhaust Gas Temperature (EGT) measurement on direct injection diesel engines with diesel-jatropha-methanol mixed fuel. The use of diesel-jatropha-methanol mixed fuels shows results in a reduce in EGT. The poor atomization of fuel tends to reduce combustion characteristics [13]. In addition, the low temperature of the heating value in a blended of diesel-jatropha-methanol fuel causes the heat produced by mixed fuels to decrease. This triggers a reduction in temperature in the combustion engine [14]. The highest decrease in EGT value occurred in DJ30M15A25 fuel at 50% loading.

Figure 2.(e) presents the results of smoke opacity testing on the use of diesel-jatropha-methanol mixed fuel indirect injection diesel engines. The use of diesel-jatropha-methanol mixed fuel results in a decrease in smoke opacity. This decrease is due to the high oxygen content in mixed fuels which promotes carbon oxidation [9]. The highest reduction in smoke opacity occurred in DJ30M15 fuel, which amounted to 34.51% at 25% loading.

4. Conclusion

From the result obtained in this study, it can be concluded that (1) The addition of jatropha in diesel-butanol fuel mixture results reduced the BSFC and BTE performance. This is due to low heating value in Jatropha and methanol compared to D100. The highest reduction in BSFC and BTE occurred in mixed fuels with the highest water content in methanol, namely DJ30M15A25. (2) The use of diesel-jatropha-methanol mixture also lower the exhaust gas oppacity compared to the D100. This is deemed due to the high oxygen content in methanol to facilitate more efficient fuel oxidation. In addition, the low viscosity in methanol also affects the reduction of smoke opacity produced by diesel engines. The highest decrease in smoke opacity occurred in DJ30M15 fuel. (3) The use of diesel fuel mixture, Europe and methanol with the highest water content (25%) is a composition of a mixture of bad fuels for increasing performance and decreasing soot emissions of diesel engines. While the composition of diesel, jatropha and pure methanol (DJ30M15) mixtures are highly recommended to improve the performance of the diesel engine.

5. Acknowledgement

The authors sincerely acknowledge the suport and facilities from Thermofluid Laboratories, Faculty of Engineering, Universitas Diponegoro.

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