Experimental Test Effect of Water Content in Methanol on the Performance and Sick Emissions of Direct Injection Diesel Engines with Jatropha Solar and Oil-Fueled Cold EGR

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Abstract.- Diesel engines are widely used as a mode of transportation because of their durability and high efficiency compared to gasoline engines. This has increased the number of diesel engine use which has an impact on increasing the amount of diesel fuel consumption and air pollution from diesel engine exhaust gases, especially soot emissions. To reduce dependence on diesel fuel and overcome these soot emissions, jatropha and methanol oil with various variations of water content are mixed into diesel fuel. Therefore, this study focuses on the effect of water content in methanol on the performance and soot emissions of diesel and jatropha diesel engines with the exhaust gas recirculation (EGR) system. Methanol is varied in the range of 5% to 15% in diesel and jatropha oil mixed fuels. The water content in methanol is varied in the range 0 to 25% at a 5% interval. Tests are carried out at a constant engine speed of 2500 rpm at a loading variation of 25% to 100% at a 25% interval. The test results showed that the mixture of the DJ30M15A20 increased torque by 3.8%, brake power by 5.3%, and decreased brake thermal efficiency of 4.8% and 4.8% opacity from the DJ30 at full load with cold EGR.

Keywords: Water, methanol, soot emissions, cold EGR, jatropha oil

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1 INTRODUCTION

The scarcity of diesel fuel and the high soot emissions due to a large number of uses of diesel engines are of concern to researchers to look for an alternative, renewable and environmentally friendly alternative fuels. Jatropha is one of the alternative fuels that is suitable because it is non-food, derived from plants that grow in a small area of water. This is because jatropha has a low calorific value [1]. Besides, diesel engines produce carcinogenic soot. Therefore, methanol additives are mixed into diesel fuel and jatropha to reduce soot emissions [2].

Addition of methanol to fuel results in an increase in torque and engine power as described by Sugeng et al. 2013 [3]. This is because methanol has a lower viscosity compared to diesel fuel, making it easier to inject into the combustion chamber. Exhaust Gas Recirculation (EGR) is one method to reduce NOx emissions by circulating some of the exhaust gas into the combustion chamber [4]. Decreasing the concentration of air in the combustion chamber causes a decrease in combustion temperature resulting in a decrease in NOx emissions. In the current study, hot and cold EGRs were applied to investigate exhaust gas temperature (EGT). Cold EGR is a part of the exhaust gas that is put back into the combustion chamber first cooled by a heat exchanger, while the hot EGR without using it is directly circulated into the combustion chamber without the cooling process.

Based on literature studies, the analysis of the effects of water content contained in methanol has never been done. Therefore, this study investigates the effect of water content in methanol on the performance and soot emissions of diesel engines fueled by a mixture of diesel fuel and jatropha oil.

2. EXPERIMENTAL SET-UP

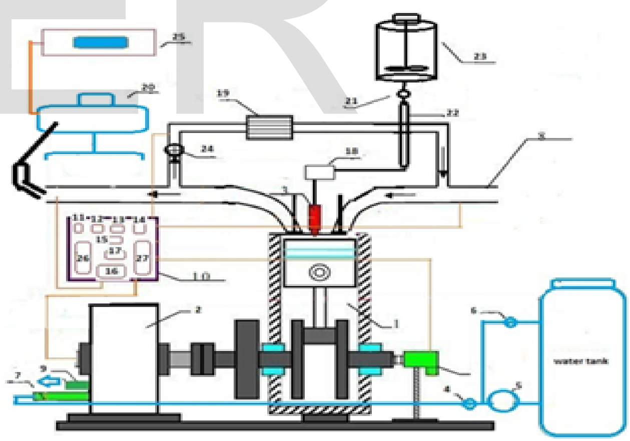

FIGURE 1. Schematic of a diesel engine testing instrument

1. Diesel engine
2. Dynamometer
3. Injector
4. Water flow valve
5. Pump Dynamometer
6. Valve By pass
7. EGR water inlet
8. Intake manifold
9. Outlet water EGR
10. Display temperature
11. Exhaust temperature
12. Intake temperature EGR
13. Discharge temperature EGR
14. Mixed temperature
15. U Manometer
16. Display Load Engine
17. Tachometer
18. Injection pump
19. EGR Cooler
20. Smoke meter
21. Fuel VALVE
22. Buret
23. Fuel Mixer
24. EGR Valve
25. Gas analyzer

The mixed fuel used in this study consisted of diesel fuel as basic fuel, Europe and methanol with variations in water content. To observe the effect of water content in methanol on performance and soot diesel engine emissions, methanol with a percentage of 5% to 15% of the volume of mixed fuels is investigated with water content in methanol in the range of 5% to 25% at intervals of 5% of total methanol volume mixed. Performance and soot emissions of diesel engines are analyzed by comparing the use of mixed fuels and pure diesel fuel. Some terms of fuel mixtures are given to facilitate analysis. D100 is pure diesel fuel, DJ30 is a mixed fuel consisting of 30% of jatropha oil and the rest is diesel fuel. DJ30MxAy represents a mixture of diesel fuel, 30% jatropha with x% methanol and y% water content in methanol. Diesel fuel in this study was produced by PT. Pertamina Tbk.

The Isuzu 4JB1 diesel engine is connected by a dynamometer (Dynomite Land & sea type water brake dynamometer and accuracy of ± 0.3Nm) to measure engine torque. Engine speed is monitored using a tachometer (TZN4S-14R Temperature Switch Autonics type and ± 0.3% accuracy). Fuel consumption is measured by monitoring the rate of decrease in the volume of mixed fuels on the burret pipe. Exhaust gas temperature is measured by using a thermocouple installed in the exhaust gas line. Fresh air velocity and exhaust gas speed in EGR are measured using an orifice to calculate fresh air requirements and EGR rates. The experimental scheme in this study can be illustrated in Figure 1. The tests were carried out at a constant engine speed of 2,500 rpm. This study also investigated the effects of EGR hot and cold use with a variety of mixed fuels. In cold EGR, some of the exhaust gas that enters the combustion chamber is first cooled by a heat exchanger. EGR valve openings are varied from 25% to 100% at 25% intervals. The specifications of the fuel used in this study can be shown in Table 1.

TABLE 1
PROPERTIES OF ALCOHOL AND DIESEL

No	Properties	Diesel	*Jatropha*	Methanol
1	cetana 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

The experiment was carried out using a 4-cylinder direct injection diesel engine whose specifications are described in Table 2. Tests are carried out at 2500 rpm constant rotation. EGR valve openings are varied from 0 to 100% at 25% intervals. Openings of 0% indicate cases without EGR. Engine load varies in the range of 25% to 100% at 25% intervals. This 100% engine load is the maximum engine load that can be achieved by the engine in this study. Variation in engine load is given by adjusting the openings of the drainage valves into the dynamometer.

TABLE 2
SPECIFICATIONS FOR DIESEL ENGINE TESTS

Properties	Diesel
Isuzu brand	Isuzu brand
Tipe 4BJ1	Tipe 4BJ1
Number of cylinders	4, vertical in-line, Direct Injection
Number of cylinders	93 mm
Step length	102 mm
Total cylinder volume	2771 cc
Compression ratio	18,2 : 1
Maximum torque	178,96 Nm (On 2000 rpm)
Maximum power	52,2 kW (On 3000 rpm)

3 RESULTS AND DISCUSSION

3.1. Brake Torque

Figure 2 shows a torque brake with a mixture of diesel fuel and European oil, and methanol as an additive for variations in the moisture content of 0 to 25% of the volume of methanol at a constant engine speed of 2500 rpm. From Figure 2 it can be observed that the brake torque decreases with the increase in the percentage of water in methanol. Brake torque decreased by 11.1% with DJ30 fuel and 5% methanol additives with 25% moisture content (DJ30M5A25). The use of a mixture of jatropha and methanol in diesel engines lowers the torque brake due to the low heating value of the fuel mixture so that the combustion in the cylinder is less effective [16]. The use of EGR increases torque caused by increasing the duration of combustion so that the pressure on the cylinder increases slightly [10]. The highest brake torque increase is 13.6% with DJ30M5A25 fuel on the hot EGR system.

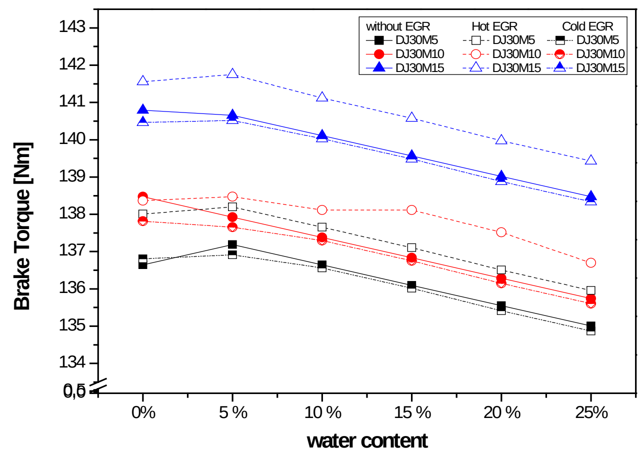

FIGURE 2. Brake torque for various fuels with variations in engine

3.2. Brake Power

Figure 3 shows the value of the brake power for various fuels in varying load levels with or without EGR hot/cold. From Figure 3 it can be observed that the brake power decreases with the increase in the percentage of water in methanol. Addition of variations in the water content of 0 to

25% of the volume of methanol at a constant engine speed of 2500 rpm as an additive to the diesel fuel mixture and jatropha oil reduces brake power 11.3% compared to that of the DJ30M15A25 fuel. The use of mixed fuel jatropha (Low Purity Methanol) LPM in diesel engines produces lower torque and power than pure diesel because of the low heating value of mixed fuels which affects the combustion process [16]. The use of EGR slightly increases engine power due to the presence of unburned fuel in the circulated exhaust gas returning to the combustion chamber [9]. The exhaust gas contributes to the next combustion cycle which results in an increase in engine power. The highest brake power increase is 15.2% with mixed fuel DJ30M15A25 on the hot EGR system.

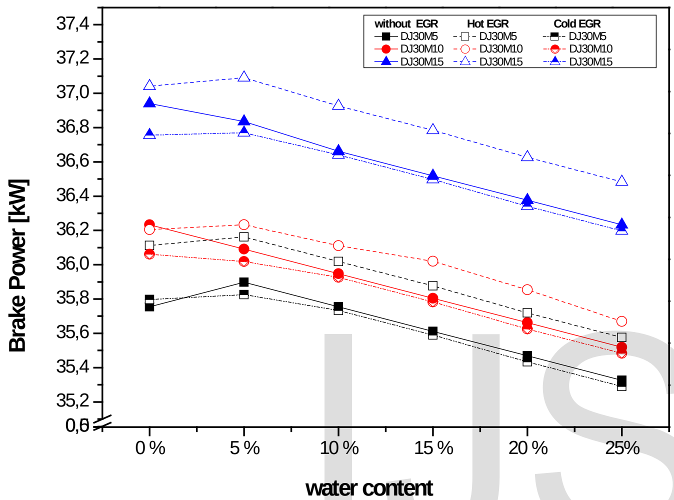

FIGURE 3. Brake power for various fuels with variations in engine load

3.3. Specific Brake Fuel Consumption (BSFC)

Figure 4 shows BSFC with a mixture of diesel fuel and European oil, and methanol as an additive for variations in moisture content from 0 to 25% of the volume of methanol at a constant engine speed of 2500 rpm. From Figure 4 it can be observed that BSFC increases with the increase in the percentage of water in methanol. BSFC increases 2.5% with DJ30 fuel and 5% methanol additives at 25% moisture content (DJ30M5A25). Increased BSFC due to lower methanol heating value than diesel fuel resulted in increased fuel consumption [12]. The use of hot EGR can reduce fuel consumption better than cold EGR. The duration of combustion increases due to high intake temperatures due to exhaust gas circulation by hot EGR [18]. It can be concluded that the use of hot EGR reduces fuel consumption lower than that from cold EGR. The use of hot EGR lowers BSFC 11.5% in DJ30 fuel mixture and 5% methanol additives with 25% moisture content (DJ30M5A25).

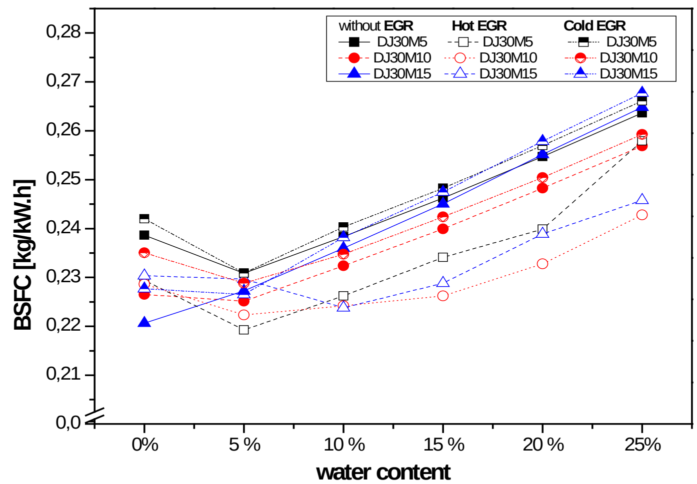

FIGURE 4. Cosumption Brake Specific Fuel for various fuels with variations in engine load

3.4. BTE

Figure 5 illustrates the value of BTE for various fuels in engine loads different from or without EGR hot/cold. In this experiment, it can be observed that BTE increases with increasing engine load. Addition of methanol as an additive for variations in moisture content from 0 to 25% of the volume of methanol at a constant engine speed of 2500 rpm resulted in an increase in BTE of 21.6% compared to that of European and diesel fuel. BTE increase is due to the high percentage of oxygen in methanol which causes repair of combustion in the combustion chamber [14]. The use of EGR causes an increase in BTE caused by an increase in the temperature of the intact manifold [19]. BTE enhancements using the hot EGR system are 7.32% with DJ30M5A25 fuel at full engine load.

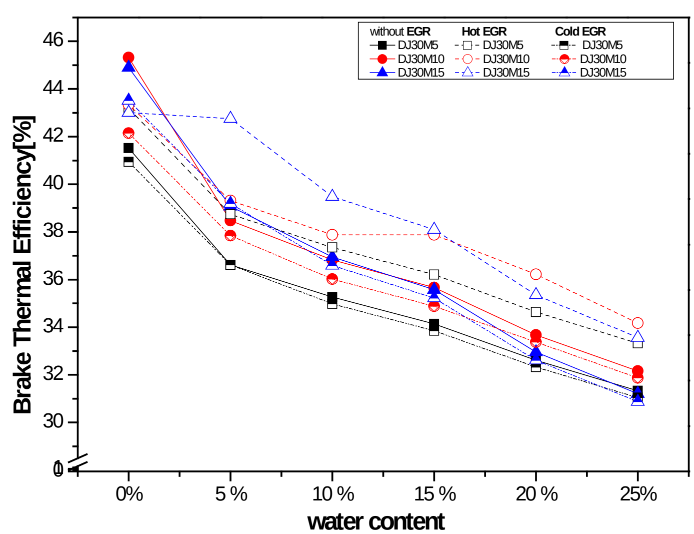

Figure 5. Thermal Efficiency Brake for various fuels with variations in engine load

3.5. EGT

Figure 6 shows the EGT value for various mixed fuels at variations in water content in methanol with or without EGR hot/cold. From Figure 6 it can be observed that EGT decreases with increasing engine load. Addition of methanol as an additive for variations in water content from 0 to 25% of the volume of methanol at a constant engine speed of 2500 rpm reduces to 36.8% with fuel DJ30M5. This results in lower temperatures in the combustion chamber. The use of EGR can reduce EGT because the amount of fresh air entering the combustion chamber decreases, so the oxygen concentration in the combustion chamber decreases [1]. The use of hot EGR reduces EGT to 40.7% with DJ30 fuel and 15% methanol additives at 25% moisture content (DJ30M15A25)

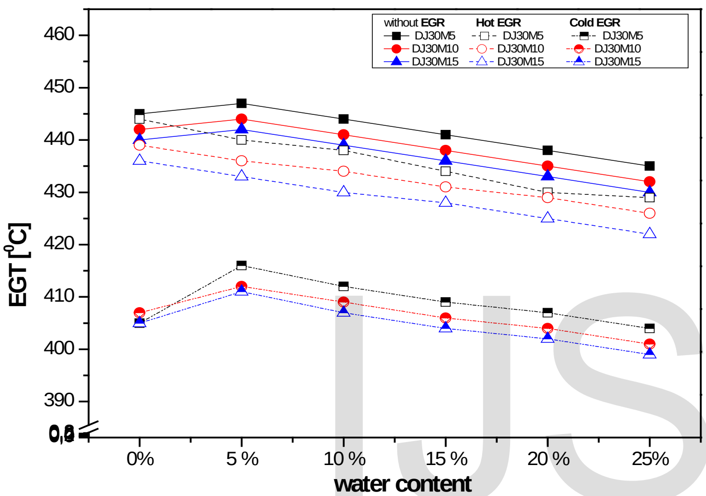

Figure 6. Exhaust Gas Temperature for various fuels with variations in engine load

3.6. Opacity

Smoke emission is represented by the opacity value. Figure 7 illustrates the opacity values for various fuels at different engine loads with or without EGR hot/cold. In this experiment, it was observed that opacity increased with increasing engine load. In this experiment, it was observed that opacity increased with increasing engine load. Opacity increased only 3.11% in addition of 15% methanol as an additive with a moisture content of 15% of the volume of methanol (DJ30M15A25) with full engine load. Increased opacity caused by high carbon content in the roar due to incomplete combustion [20]. The use of EGR reduces the oxygen concentration in the combustion chamber resulting in an increase in opacity caused by a decrease in carbon oxidation [21]. The use of cold EGR increases the opacity to 28.9% with DJ30 fuel and 15% methanol additives at 25% moisture content (DJ30M15A25).

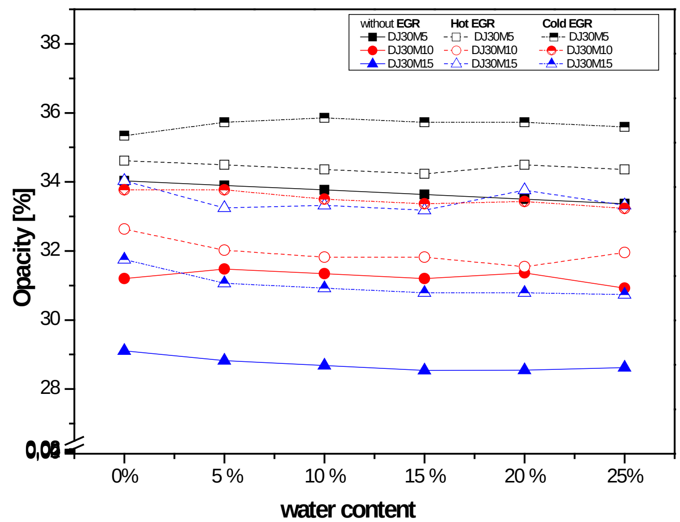

Figure 7 Opacity for various fuels with variations in engine load

Conclusion

From the results of this study, it was found that the use of a mixture of diesel fuel and jatropha oil, as well as methanol as an additive for variations in water content 0 to 25% of the volume of methanol at a constant engine speed of 2500 rpm, had an impact on:

1. Engine performance and exhaust emissions with the EGR system. From this experiment it was found that torque and brake power increased by 11.1%, adding 5% methanol with 25% moisture content to the hot EGR system. BSFC decreased by 11.5% on the hot EGR system with DJ30M5A25 fuel.
2. BTE increased by 31.2% with DJ30M5A25 fuel. In this test, the EGT was reduced by 7.03% with DJ30M5A25 fuel
3. Opacity increased by 21.04% with DJ30M5A25 fuel in the cold EGR system.

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