

# Effect of Wet-Ethanol on Fuel Consumption and Soot Emissions on Direct Injection Diesel Engines with Jatropha and Solar Cold EGR System

*by* Nazaruddin Sinaga

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## <sup>5</sup> Effect of Wet-Ethanol on Fuel Consumption and Soot Emissions on Direct Injection Diesel Engines with Jatropa and Solar Cold EGR System

Ahmad Faoji,<sup>1</sup> Syaiful<sup>1</sup> dan Nazarudin Sinaga<sup>1</sup>

### 1. Introduction

Diesel engines are an essential part of the transportation mode. The use of diesel engines will continue to increase as the volume of motorized vehicles increases. However, smoke emissions continue to be the biggest threat to the diesel engines for health and the environment [1]. Besides, the use of diesel engines in depletion of petroleum reserves [2]. Jatropa is an alternative to fuel to overcome fears of depletion of petroleum reserves. Jatropa was chosen because it was produced from non-food ingredients [3].

The use of jatropa as a mixture of material in diesel fuel produces higher soot emissions than diesel fuel. Besides, the value of power and torque produced by diesel engines is also lower than diesel fuel because of high viscosity and low calorific value of jatropa [4].

According to Sugeng and Syaiful, the addition of liquid alcohol in a mixture of diesel fuel and Europe can reduce the emissions of diesel engines. The higher the alcohol content, the more soot emissions decrease [5]. Wet-ethanol is a high-octane derivative of alcohol so that it can be used as a mixture of fuel. Based on the tests conducted by Abdul K. et al., The addition of ethanol to diesel fuel produces soot emissions and lower fuel consumption than pure diesel fuel. High oxygen content and low viscosity in ethanol are the main factors in the decline. The same tendency also occurs in Cenk S study (2010) [6]. Based on the above, this study observed the effect of using ethanol on fuel consumption and soot emissions from the EGR cold system.



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## 2. Research Methods

The fuels used in this study are diesel, castor oil, and wet ethanol. Diesel fuel is produced by PT. Pertamina, Tbk. jatropha and wet ethanol were obtained from the Indrasari chemical shop, Semarang. The percentage of castor oil volume is 10% while the percentage of wet ethanol volume tested is 5%, 10% and 15% of diesel fuel amount, respectively called DJ10WE5, DJ10WE10, DJ10WE15. Mixing fuel is prepared before the start of the experiment to ensure that the mixture is homogeneous. A stirrer was used when mixing the fuel.

Table 1. Fuel properties

Properties	Diesel	Jatropha	Wet-ethanol
Cetane Number	48	41.8	5-8
Water Content (% v)	0.05	3.16	1.8
Viscosity (at 400 c (mPa.s)	2.0-5.0	3.23	2.51
Calorific Value (MJ / kg)	45.21	37.97	26.8
Flash Point (0C)	60	198	38
Oxygen content (%)	-	10.9	34.8

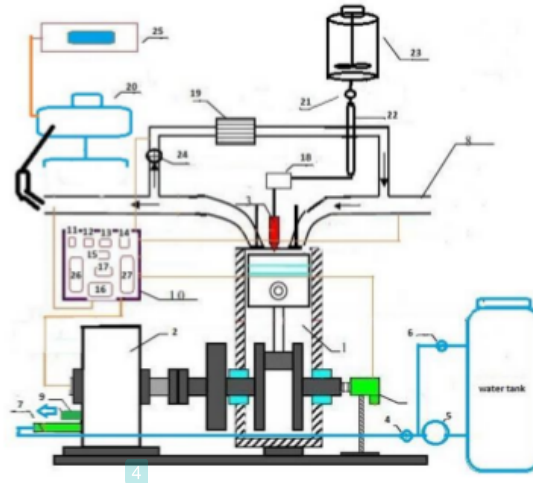


Figure 1. Experimental set-up

Tests carried out with the Isuzu 4JB1 4-cylinder direct injection diesel engine. Mixed diesel, oil distance, and wet ethanol, fuels have arranged a percentage before the experiment begins. Because of the high polarity of wet ethanol, it is difficult to blend with diesel, and the mixer 23 is used to obtain a homogeneous fuel mixture. The location of the mixer is placed higher than the engine so that the fuel mixture flows into the fuel injector (3) via valve (22) and burette (21) based on the principle of gravity and assisted by the fuel pump 18 installed on the engine. A burette (21) is used to measure fuel consumption, where each volume of fuel is 30 ml calculated in their time. After that, the fuel is sprayed into the combustion chamber using fuel injection.

A tachometer (17) was used to monitor the engine speed detected by proximity sensors. A dynamometer (2) was applied to measure the brake torque produced by a diesel engine. This was done by engine shaft coupling with the dynamometer shaft. Engine load varies from 25% to full load capability achieved by the flow rate of water flowing to the dynamometer. Water was pumped by a water pump (5) to the dynamometer. The amount of torque released was read by a tension load sensor mounted on the torque arm on the dynamometer then tells on the load screen (16).

The experiments were carried out at a fixed engine speed of 2500 rpm with variations in the concentration of mixed fuels. Some of the exhaust gas is either directly recirculated (Hot EGR) or cooled by heat exchangers (Cold EGR) (19). The percentage of EGR leads to the intake manifold (8) for mixing with fresh air through the inlet valve openings (24). In each variation, the test was carried out three times, and the uncertainty value in percent was taken from the test results.

The thermocouple K type was installed to measure temperature in the exhaust manifold, EGR inlet, EGR outlet, and the intake manifold and engine block where the measurement results are notified by the thermocouple display (11-15). In order to measure the air mass flow rate and EGR level, the orifice plate applied by U manometer 1 (27) and U manometer 2 (26) was mounted on the intake manifold and the EGR input channel. As for measuring smoke emissions, meter smoke (OTC 495) (20) plus the gas analyzer display (25) was applied.

### 3. Result and Discussion

#### 3.1. Test results of Brake Spesifik Fuel Consumption (BSFC)

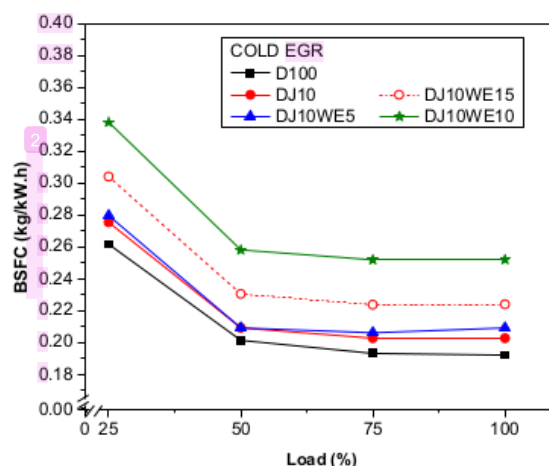


Figure 2. Graph of the effect of wet ethanol on Brake Specific Fuel Consumption (BSFC)

Figure 2 shows the BSFC value of a decrease in each fuel test. The physiochemical properties of fuels, such as viscosity and oxygen content in wet ethanol, affect the combustion of diesel engines [7]. However, the presence of jatropha and wet ethanol in diesel fuel causes the BSFC value of mixed fuels to be higher than pure diesel (D100) because of lower calorific value of jatropha oil [8]. The highest BSFC value is observed in the use of DJ10WE10 fuel by 11% for 25% load.

a. The test results in smoke opacity

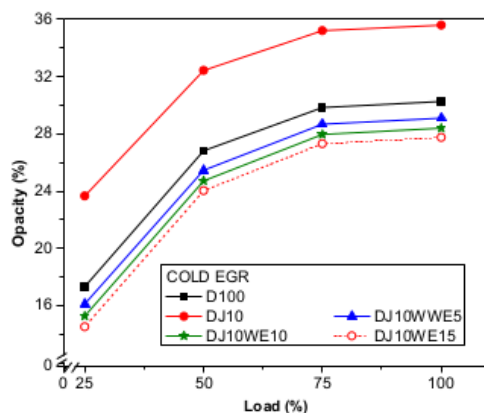


Figure 3. Graph of wet ethanol effect on Smoke Opacity

Figure 3 describes the smoke opacity test results. The smoke opacity value increases as the load percentage increases. However, the addition of wet ethanol to a mixture of diesel fuel and jatropa produces a decrease in smoke opacity because the high oxygen content in wet ethanol promotes carbon oxidation [9]. The highest reduction in smoke opacity is for the use of 16%DJ10WE15 fuel at 25% load.

b. The Test result in Exhaust Gas Temperature (EGT)

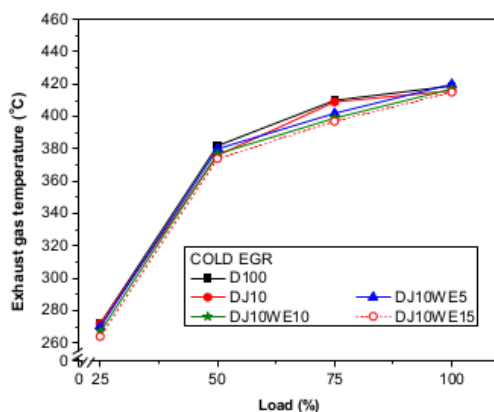


Figure 4. Graph of wet ethanol effect on Exhaust Gas Temperature (EGT)

Figure 4 presents a graph of the results of testing the exhaust gas temperature (EGT). In general, the use of diesel, jatropa, and wet ethanol mixed fuels shows an increase in exhaust gas temperature. But the EGT value is still lower than pure diesel. The poor atomization of fuel tends to reduce the quality of combustion [10]. Besides, the low calorific value and high viscosity in jatropa as blended fuels result in lower heat compared to D100 [11]. The highest decrease in EGT value is found for the use of DJ10WE15 fuel by 3% at 100% load.

#### <sup>2</sup>**4. Conclusion**

The following are the main conclusions obtained in the study of the effect of low levels of wet ethanol on BSFC and Smoke Opacity on direct injection diesel engines with EGR systems R:

- a. The addition of wet ethanol to the use of a mixture of diesel fuel and jatropa produces a higher BSFC value than D100.
- b. High oxygen content and low viscosity in wet ethanol cause smoke opacity to be lower than D100.
- c. The heating value contained in jatropa and wet ethanol also results in a decrease in the value of exhaust gas temperature.

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The author would like to thank the entire Thermofluid Laboratory team, which is one of the laboratories owned by the Undip Mechanical Engineering Department. This laboratory examines the phenomena that occur in the existing machining process and machine performance testing, especially in the field of Energy Conversion.

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