

Effect of Premium-Butanol Blends on Fuel Consumption and Emissions on Gasoline Engine with Cold EGR System

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Effect of Premium-Butanol Blends on Fuel Consumption and Emissions on Gasoline Engine with Cold EGR System

Firman Lukman Sanjaya ^{1,*}, Syaiful ¹ dan Nazarudin Sinaga ¹

1. Introduction

The growth of motorized vehicles has a serious impact on increasing fuel consumption and exhaust emissions. In addition, poor fuel characteristics such as low heating values lead to increased fuel consumption and exhaust emissions. Therefore, to meet fuel requirements due to an increase in vehicle volume there need to be alternative fuels [1]. Butanol has almost the same characteristics as gasoline. Butanol is usually used as a fuel mixture for gasoline engine vehicles. This is to meet fuel requirements and reduce knocking on the engine so that it makes combustion more efficient. In addition, the relatively high combustion temperature value of butanol helps reduce fuel consumption. Further, higher heat of evaporation in butanol causes better combustion and reduces fuel consumption [2,3]. The high oxygen content in butanol supports the combustion oxidation process. This increases the thermal efficiency of the engine and reduces exhaust emissions [4,5].

Exhaust Gas Recirculation (EGR) is a technology used to reduce NO_x and reduce the temperature of the combustion chamber [6,7]. EGR recirculates as exhaust gas has been cooled to the combustion chamber. The EGR brings the unburnt fuel particles back to the cylinder. The exhaust gas contributes to the next combustion cycle so that the engine's performance is better [8]. The EGR system also reduces fuel consumption [9].



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2. Methods

In this study, the fuel used is premium and butanol. Premium fuel is obtained from PT. Pertamina Tbk. and is used without further purification. The variation of fuel mixture is premium 100% (P100), premium 95% butanol 5% (P95B5), premium 90% butanol 10% (P90B10) and premium 85% butanol 15% (P85B15). Mixed 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 parameters of Premium and Butanol

No	Properties	Premium	Butanol
1	Octane Number	88	98.3
2	Density 15°C (kg/m ³)	744	815
3	Calorific Value MJ/kg	42.7	33.3
4	Water content (%V)	0.003	>5
5	Viscosity (mm ² /s)	0.22	2.63
6	Oxygen content (%)	2.7	21.69

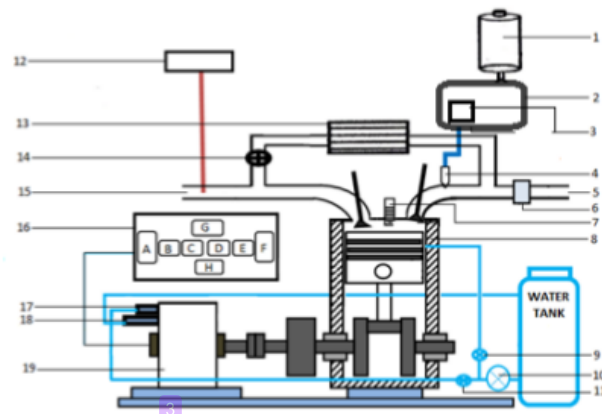


Figure 1. Experimental set-up

The test is carried out with a Toyota 7K gasoline engine. A mixture of premium and butanol, fuel has set the percentage before the experiment begins. Mixer (1) 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 to the fuel injector (4) based on the principle of gravity and is assisted by a fuel pump (3) installed on the engine. Burette (2) is used to measure fuel consumption, where each volume of fuel is calculated as 90 ml in time. After that, the fuel is sprayed into the combustion chamber using fuel injection.

Experiments were carried out at engine speed of 2500 rpm to 4000 rpm with variations in the percentage of mixed fuels. The dynamometer (19) is applied to measure the brake torque produced by a gasoline engine. Constant engine load is fixed at 25% of maximum engine capability. Engine load is achieved by changing the flow rate of water flowing on the dynamometer. Water flowing from the water tank is pumped by a water pump (10) to the dynamometer. The amount of torque generated on the dynamometer will display a load screen (16).

EGR (13) re-circulates some of the exhaust gas in the intake manifold (5). Type K thermocouples are used to measure temperature. Thermocouples are installed in the exhaust manifold, EGR Inlet, EGR Outlet, intake manifold and engine cylinder. The measurement results are displayed on the

thermocouple screen (16). An orifice plate is a tool that can be used to measure EGR air mass flow rates. An orifice plate is applied to the manometer (16) and mounted on the intake manifold and EGR flow. A gas analyzer (12) is used to measure exhaust emissions.

3. Result and Discussion

Figure 2 shown the Specific Fuel Consumption Brake (BSFC) decreases with increasing engine speed (rpm). The highest BSFC value occurs in the P85B15 fuel mixture. Premium produces BSFC 0.291 kG.kW/hour at 4000 rpm. The BSFC value produced by the mixture of P85B15 is 0.296 kG.kW/hour at 4000 rpm. This value increased by 1.9% compared to using premium. Butanol has a low calorific value which decreases the temperature of the combustion chamber. This causes an increase in fuel consumption [3,10,11]. The use of EGR can reduce BSFC. BSFC experienced the largest decrease in the P90B10 mixture of 14.03%. The EGR system reduces fuel consumption and NOx emissions [9].

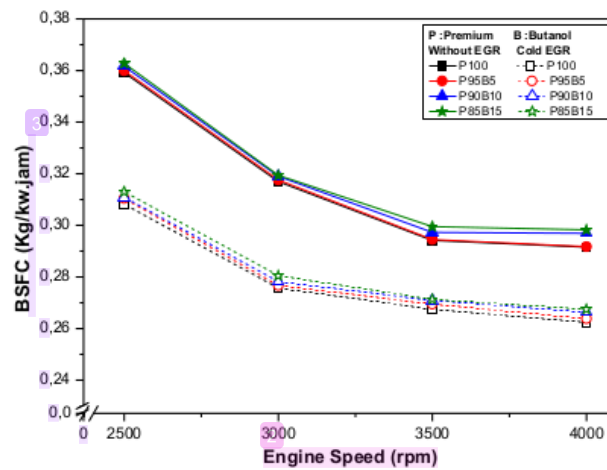


Figure 2. Fuel consumption on gasoline engines uses premium and butanol blend with the Cold EGR system and without the EGR system.

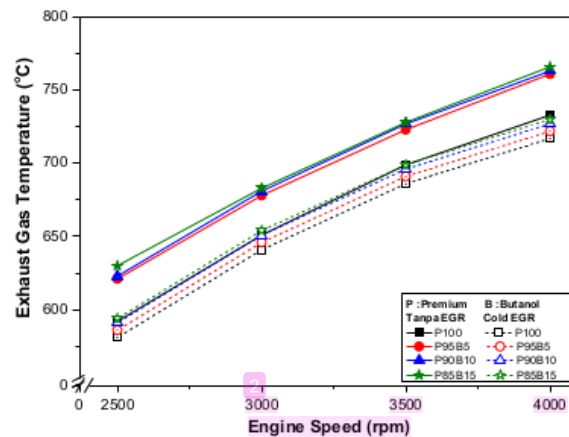


Figure 3. Exhaust Gas Temperature on a gasoline engine uses premium and butanol blend with the Cold EGR system and without the EGR system.

Figure 3 shows the increase in Exhaust Gas Temperature along with the increase in engine speed. The highest EGT occurs in the P85B15 fuel mixture. The premium EGT produced is 592 °C at 2500 rpm. The P85B15 fuel mixture produces EGT of 630 °C at 2500 rpm. EGT has increased by 6.4% compared to premium. Butanol has a higher flame speed than premium. High oxygen content in butanol makes combustion better. this increases the pressure and temperature of the cylinder [12]. Butanol has a high latent heat which increases the compression temperature and exhaust gas temperature [13]. The Cold EGR system decreases the EGT value of 3,2% compared without EGR. The decrease is due to the amount of oxygen circulated into the lower combustion chamber [14].

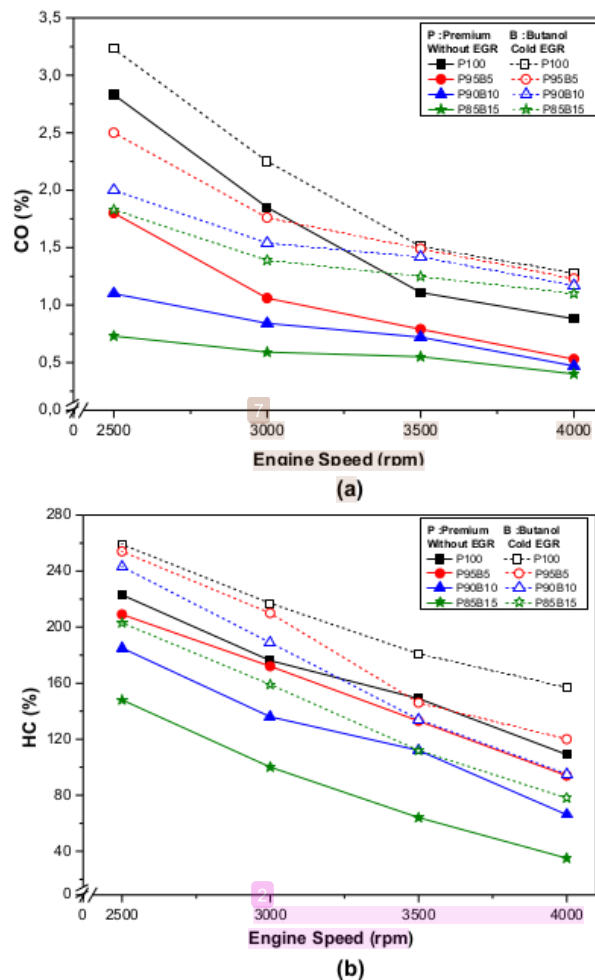


Figure 4. Exhaust emissions of (a) CO and (b) HC on a gasoline engine uses premium and butanol blend with the Cold EGR system and without the EGR system.

Figure 4.(a) show a decrease in CO along with the increase in engine speed. The highest decrease occurred in the P85B15 fuel mixture. The value of CO emissions is 2.83% when the engine uses premium fuel at 2500 rpm. The P85B15 fuel mixture produces CO emissions of 0.73% at 2500 rpm.

This value decreased by 74.2% compared to premium. Butanol has a high oxygen content which causes an increase in leaning effects and more complete combustion. This results in a decrease in CO emissions [15,16]. The use of EGR increases the concentration of CO₂ emissions. Low oxygen concentration produces a rich air-fuel mixture in various locations in the combustion chamber. This heterogeneous mixture does not burn completely and produces higher carbon monoxide [17]. The highest CO emission value occurs in the P90B10 fuel mixture using the Cold EGR system. The value of CO emissions is 0.47% without Cold EGR and 1.47% in the Cold EGR system at 4000 rpm.

Figure 4.(b) also show a decrease in HC along with the increase in engine speed. HC emissions are the highest decreases in the P85B15 mixture. HC emission value uses premium fuel of 149% at a speed of 3500 rpm. The P85B15 fuel mixture has 80% HC emissions at a speed of 3500 rpm. HC emissions decreased by 46.3% compared to premium. The Higher oxygen content of butanol increases combustion efficiency and decreases the concentration of HC emissions. In addition, higher flame speeds in butanol result in more complete combustion and reduced HC emissions [16]. The use of EGR increases the concentration of CO emissions. Low oxygen concentration produces a rich air-fuel mixture in various locations in the combustion chamber. This heterogeneous mixture does not burn completely and produces higher HC [17]. The highest HC emission value occurs in the P85B15 fuel mixture using the Cold EGR system. The value of HC emissions is 47% without Cold EGR and 90% in the Cold EGR system at 4000 rpm.

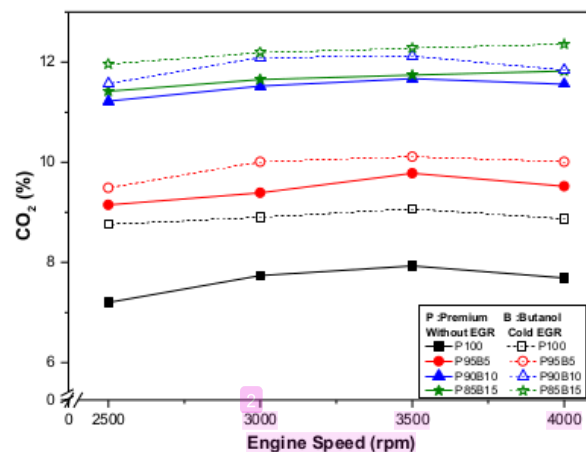


Figure 5. exhaust emissions CO₂ on a gasoline engine uses premium and butanol blend with the Cold EGR system and without the EGR system.

Figure 5 show an increase in CO₂ along with the increase in engine speed. The value of CO₂ emissions experienced the highest increase occurred in the P90B10 fuel mixture. CO₂ emissions of 7.2% when the engine uses premium fuel at 2500 rpm. The P90B10 fuel mixture produces CO₂ emissions of 9.15% at 2500 rpm. The value of CO₂ emissions increased by 58.6% compared to premium fuel. CO₂ emissions increase because oxygen in butanol contributes to increasing the combustion rate. Oxygen in combustion will produce more carbon which can be converted to carbon dioxide. More amount of CO₂ in exhaust emissions shows perfect fuel combustion [12,16]. The addition of the EGR system increases CO₂. The exhaust gas that is recirculated replaces fresh air. Exhaust gases that enter the combustion chamber include CO₂ and H₂O (carbon dioxide and water vapor) produced from the combustion residue [17]. This is what causes an increase of 19.04% CO₂ emissions by using the Cold EGR system on the engine.

4. Conclusion

Butanol renewable fuel complementary can be used as a solution to the need for increased fossil fuels and exhaust gas emissions. The use of premium and butanol mixed fuels lowers BSFC but the value is higher than pure premium. The use of the Cold EGR system is proven to reduce BSFC up to 14.04%. EGT has increased with the addition of butanol to fuel. However, the EGT value has decreased when using the Cold EGR system. The high oxygen content in butanol results in reduced CO and HC emissions. The use of the Cold EGR system increases CO and HC emission values. However, CO₂ emissions in the use of premium and butanol mixtures have increased. Increasing CO₂ values shows that combustion is more perfect.

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