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Research Paper

Effect of Cassava Biogasoline on Fuel Consumption and CO Exhaust Emissions

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Abstract

Cassava biogasoline was tested on electronic fuel injection vehicles in urban traffic conditions with varying engine load. Biogasoline tested includes B0, B10, B20, and B30. The engine speed was operated within 750 to 1800 rpm (low-speed range) to simulate urban traffic condition. The engine load was varied through the operation of air conditioner (AC). Fuel consumption was measured in real terms (ml/s) and CO emissions were measured with the Hesbon HG 520 Engine Gas Analyzer (EGA) in the percentage of total exhaust gas. The results showed that B10 has the lowest fuel consumption of 0.24 ml/s in conditions without AC and 0.41 ml/s with AC. Meanwhile, CO emissions tend to be constant with change in the proportion of cassava biogasoline and increased with additional AC load.

Key words: Biogasoline, Fuel consumption, CO emissions

Abstrak

Biogasoline singkong diujikan pada kendaraan *electronic fuel injection* pada kondisi lalu lintas perkotaan dan variasi pembebanan mesin. Biogasoline yang diujikan meliputi B0, B10, B20, dan B30. Kondisi lalu lintas perkotaan menjadikan putaran mesin terkontrol pada kisaran putaran rendah, ± 750 s.d 1800 rpm dengan air conditioner (AC) sebagai variasi beban mesin. Konsumsi bahan bakar diukur secara riil (ml/s) dan emisi CO diukur dengan Engine Gas Analizer (EGA) Hesbon HG 520 secara persentase dari total emisi gas buang. Hasil penelitian menunjukkan B10 menghasilkan konsumsi bahan bakar terendah yaitu 0.24 ml/s pada kondisi tanpa AC dan 0.41 ml/s dengan AC. Sementara itu, Emisi CO cenderung konstan dengan perubahan proporsi biogasoline singkong dan meningkat dengan tambahan beban AC.

Kata Kunci: Biogasoline, Konsumsi bahan bakar, Emisi CO

1. Introduction

In 2017, Central Bureau of Statistics Republic of Indonesia (*Badan Pusat Statistik*, BPS) released data on the number of motorized vehicles in Indonesia reaching 138,556,669 units [1]. The number increased by 9,275,590 units compared to the previous year. The types of motorized vehicles include passenger cars, bus cars, freight cars and motorbikes.

The increasing number of motorized vehicles has caused serious problems in the field of energy and environment [2]. In the energy sector, there is an increase in fuel demand. According to BPH Migas, in 2018, it is estimated that fuel consumption has reached 75 million kilo liters and has increased by 1.44 million kilo liters compared to 2017. The increase in the number of motorized vehicles has an adverse effect on the environment (air quality index). Motorized vehicles become a source of carbon monoxide produced from incomplete combustion processes; which contribute to 75% of total carbon dioxide in rural area and 95% in urban area [3].

The increase in motor vehicles has also caused traffic congestion in almost all major cities in Indonesia. For example, a study by Prasetyo et al. suggested that traffic jam at one traffic light point brings a loss of IDR 4,950,000 to IDR 9,940,000 per day [4]. Moreover, a report from the University of Indonesia environmental expert, Dr. Firdaus Ali, stated that the loss due to traffic congestion in Indonesia reached IDR. 28.1 trillion per year [5].

Therefore, biofuels such as biogasoline, both as it is and as a mixture, are needed for a sustainable transportation system. Biogasoline itself is an alternative energy produced from plants such as corn, sugar cane, and cassava [6]–[9]. Biogasoline from biomass is able to produce lower exhaust emissions compared to gasoline [10]. In 2013, 85% of biofuel supplies produced by the United States and Brazil came from corn and sugar cane [11]. The use of biogasoline in vehicles reduces carbon dioxide emissions by 48% compared to conventional gasoline [12]. The use of biogasoline may also increase the thermal efficiency [13].

The use of biogasoline as an alternative energy is expected to be implemented in various types of vehicle technology. Previous studies have confirmed that the use of biogasoline in the Toyota Corolla Twincam AE92 type carburetor can reduce CO emissions in idle rotation testing [14]. Currently, the fuel control system technology has switched to Electronic Fuel Injection (EFI) with its variations. EFI technology is designed to allow the acquisition of lambda (λ) to approach ideal values under various engine conditions [15]. Lambda is the number used to represent the ideal air-fuel ratio (AFR), $\lambda = 1$. Based on this background, this study specifically intends to address the effect of the use of cassava biogasoline on fuel consumption and exhaust emissions on EFI vehicles in conditions of urban traffic and varying engine load.

2. Method

2.1. *Engine preparation*

Cassava biogasoline has been applied to the 1300 CC EFI car equipped with an AC system. Cassava biogasoline has been made through the process of cassava glucose fermentation. The experiment was conducted by firstly modifying the fuel components through the addition of a special fuel tank, as shown in Figure 1. EFI engine scheme is presented in Figure 2 [16].

Figure 1. Special fuel tank for cassava biogasoline experimental test

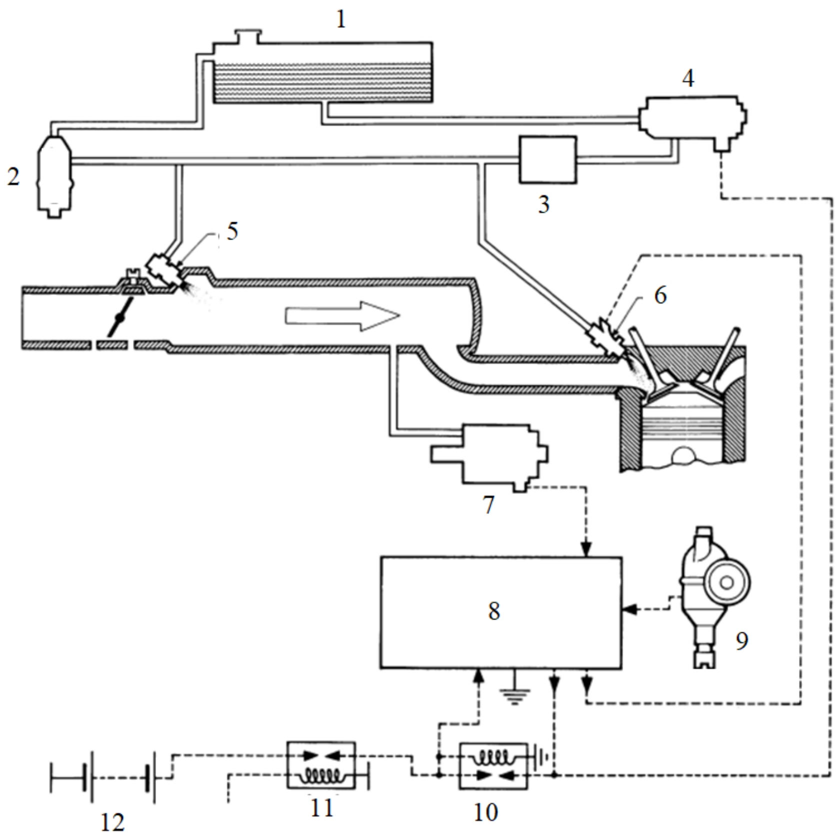

Figure 2. EFI fuel system: (1) fuel tank, (2) regulator, (3) filter, (4) fuel pump, (5) cold start injector, (6) injector, (7) pressure sensor, (8) ECU, (9) distributor, (10) fuel pump relay, (11) main relay, dan (12) battery.

2.2. *Fuel consumption measuring*

Biogasoline used in this study included B0 (100% gasoline RON-92), B10 (10% cassava bioethanol and 90% gasoline RON-92), B20 (20% cassava bioethanol and 80% gasoline RON-92), and B30 (30% bioethanol cassava and 70% gasoline RON-92). All specified mixtures are tested like in urban cycle conditions; with and without AC system load.

Testing the fuel consumption involves measuring cups to measure the volume of fuel (ml) spent in each treatment (s). Fuel consumption is calculated from the start of the engine until the engine runs out of fuel supply. Therefore, manipulation of the fuel pump relay line is required.

Tests were carried out on vehicles running in static conditions. The engine is set to run for 10 minutes under urban traffic condition, with sequence of: 2 minutes stationary, 2 minutes low engine speed (1800 rpm), 2 minutes stationary, 2 minutes low engine speed (1800 rpm), and stationary for the last 2 minutes remaining. After 10 minutes (600 seconds), the fuel supply is cut out and the engine is left until it stops. The evolution of engine speed during the test is presented in Figure 3.

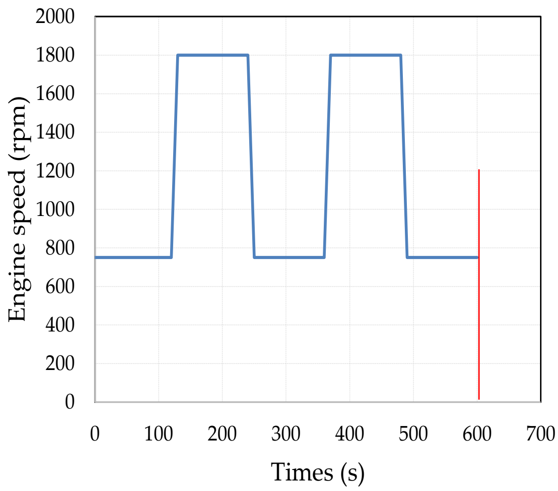

Figure 3. The evolution of engine speed during the test (The vertical red line in the 600th second indicates the cease of fuel pump operation)

2.3. *Emission measuring*

Exhaust emission testing uses Hesbon HG 520 Engine Gas Analyzer (EGA) at idle rotation. The exhaust emission check was done by firstly conducting a visual inspection to ensure all tools and components are in normal condition, especially to avoid leakage in the vehicle exhaust pipe. After the visual inspection, the engine was turned on and left idle until it reaches steady engine condition. Next, the EGA probe was placed in the exhaust pipe and the engine was accelerated to 3000 rpm for 30 seconds. Finally, the engine was left to idle for a few seconds to obtain the emissions data.

3. Result and Discussion

3.1. *Fuel consumption*

The results of the fuel consumption test and operational time are presented in Table 1. Each fuel was tested twice for condition with and without AC load. The comparison of the fuel consumption is presented in Figure 4. It is discovered that the use of biogasoline can reduce the fuel consumption. Highest reduction of fuel consumption is found with B10 fuel without AC load.

Table 1. Fuel consumption test results

Fuel	AC Load	Time (s)	Consumption	
			(ml)	(ml/s)
B0	Off	613.25	236	0.38
B0	On	613.14	286	0.47
B10	Off	614.01	148	0.24
B10	On	613.23	250	0.41
B20	Off	614.55	232	0.38
B20	On	614.03	272	0.44
B30	Off	614.45	228	0.37
B30	On	614.20	269	0.44

3.2. *Emission*

Emission test is performed at idle speed and engine operating temperature. In this study, CO and O_2 are shown in percentage of total emission. CO is a harmful component in exhaust gas that originated from incomplete combustion process. Mixture is considered lean if value of λ is larger than one ($\lambda > 1$) and rich if value of λ is less than one ($\lambda < 1$). The O_2 content in the exhaust gas is used to ensure the AFR (λ) value can be used as a reference. O_2 value above 3% is confirmed to have an exhaust leak and therefore the AFR (λ) value cannot be used as reference. The results of the exhaust emission tests for all fuels tested are presented in Table 2.

Table 2. Exhaust emission test results with biogasoline

Fuel	AC Load	CO (%)	Lambda (λ)	O_2 (%)
B0	Off	0.01	1.003	0.13
B0	On	0.01	1.002	0.09
B10	Off	0.01	1.002	0.07
B10	On	0.02	1.000	0.04
B20	Off	0.03	0.999	0.10
B20	On	0.04	0.998	0.06
B30	Off	0.01	1.003	0.09
B30	On	0.02	1.002	0.09

Based on Table 2, it is found that the percentage CO emissions with various percentage of biogasoline variations tend to be the same. The largest difference is found in the percentage of CO value of B20; which is 0.04% and 0.03% with and without operating AC, respectively. It is also discovered that additional load from operating AC tends to increase the CO emissions. Based on the Government Regulation No. 5/2006, the maximum CO gas emission limit is 1.5%; Therefore, CO emissions on EFI engines with various biogasoline mixes are still within the regulation limit. Breakdowns of CO, λ, and O_2 comparisons are presented in Figure 5, Figure 6, and Figure 7, respectively.

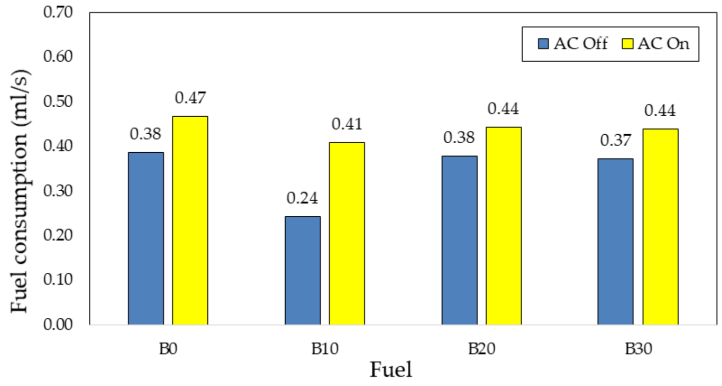

Figure 4. Comparison of fuel consumption with and without AC load.

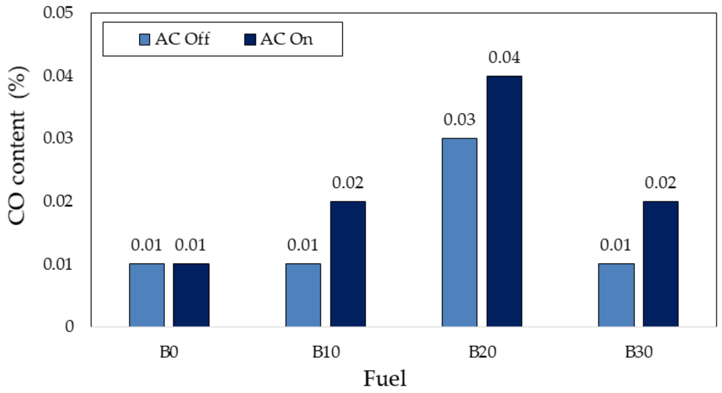

Figure 5. Comparison of CO emission with and without AC load.

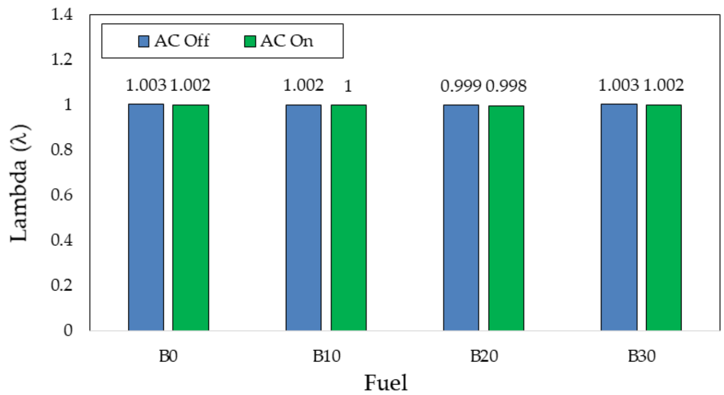

Figure 6. Comparison of lambda value with and without AC load.

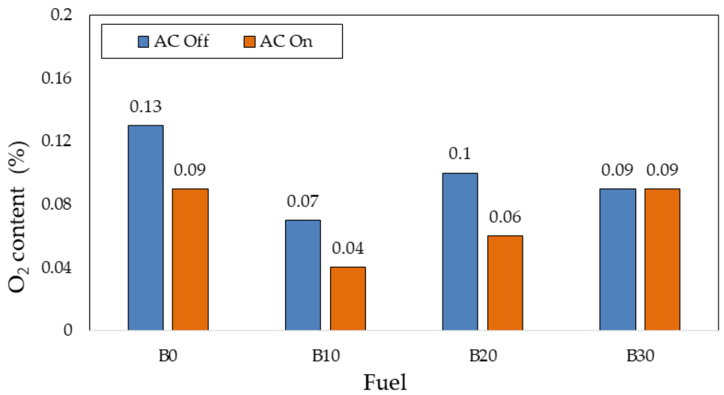

Figure 7. Comparison of O_2 content with and without AC load.

4. Conclusion

Based on the study conducted, it can be concluded that cassava biogasoline is a viable alternative fuel for EFI engine. B10 fuel mixture is found to have the lowest fuel consumption (0.241 ml/s) when used under urban traffic condition, compared to B20 and B30 mixtures. In addition, the results of emission tests showed that cassava biogasoline (B10, B20, B30) produces CO between 0.1-0.4%, which is still under government regulation limit of 1.5%.

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