THE EFFECT OF GASOLINE FUEL AND BIOGAS ON ENGINE PERFORMANCE AND EXHAUST EMISSIONS

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ABSTRACT

In this study, experiments were carried out with the use of gasoline, gasoline with a mixture of biogas with variations of 1 liter/minute, 3 liters/minute, and 5 liters/minute using a gasoline engine with a volume of 100 Cm^3 with a maximum throttle position with the addition of an engine speed of 5500 - 2000 rpm. The results of the study show the highest brake torque is 18.01 Nm at B3 at 2000 rpm engine speed, and the highest brake power at 2500 rpm engine speed reaches 365.43 Watt at B3.Brake-specific fuel consumption(BSFC) the highest is gasoline 0.0206 g/Watt.minute and B3 0.0151 g/Watt.minute. The CO and CO_2 emissions of gasoline fuel are higher than that of gasoline-biogas mixture fuels, CO gasoline 0.06% and CO B3 0.02%, CO_2 gasoline 15.77%, and CO_2 B3 10.85 %. So overall, the use of a mixture of gasoline and biogas is more effective, especially at high loads with an increase in temperature.

Keywords: gasoline, biogas, engine performance, CO and CO2 emissions.

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INTRODUCTION

The need and demand for energy have steadily increased over the past few years, mainly due to the strong industrial development [1], [2]. Most of the world's energy needs are met by fossil-based energy sources, the combustion of which promotes ecological balance and causes serious environmental changes [3]-[6]. Currently, many studies are being carried out to reduce the harmful effects of exhaust gas emissions arising from the use of gasoline, diesel, and LPG fuels in internal combustion engines (ICE) [7]-[9]. One alternative fuel to reduce fossil fuel consumption is to use alternative fuels such as biogas[10], [11].

Biogas is an environmentally friendly fuel for ICE and can be produced through anaerobic fermentation of various industrial, agricultural and sewage, animal manure, straw, and household waste and contains about 50-70% methane (CH_4), 25-50% CO_2, 1- 5% hydrogen (H_2, 0.3-3% nitrogen (N_2) [12]-[15]. In a spark-ignition engine, it is possible to replace a gasoline-fueled engine using biogas, but the operation of a spark-ignition engine with biogas containing significant fractions of inert gases such as CO_2 and N_2 shows a decrease in performance compared to natural gas or gasoline [16], [17]. Gasoline and biogas fuels require an earlier ignition timing because the combustion process for biogas fuels is slower than for gasoline fuels [18]. The low calorific value of biogas has lower thermal efficiency than gasoline and remains the same at low temperatures and high output. Noel et al[19]in the study concluded that gasoline has a very positive pattern of increasing thermal efficiency of 0.90 while biogas has a sharp decreasing pattern even though the torque increases by 19.36 Nm. Simsek*et al* 2021 [18] examined the increase in compression ratio and concluded their research that the value of BSFC increases with the use of biogas compared to gasoline, and this increase increases with increasing biogas ratio.

In the literature review, there are studies related to the use of biogas in different volumetric ratios, the authors would like to see the impact of biogas utilization at different levels evaluated in single-cylinder gasoline engines, at various engine speed values. The author focuses on adding biogas fuel to gasoline engines with variations in the flow rate of biogas, engine performance, CO, and CO_2 emissions

EXPERIMENTAL METHOD

In an experimental study using a gasoline engine with gasoline fuel mixed with biogas with variations in flow rates: 1 liter/minute (B1), 3 liters/minute (B2), and 5 liters/minute (B3) with fuel qualifications in Table-1. Experimental testing using a single-cylinder gasoline engine with the specifications in Table-2. Before the engine performance and emission results are evaluated, the engine is turned on until it reaches the highest working temperature and engine speed, the experiment is carried out at the maximum throttle position with the addition of braking load until the specified engine speed is reached, namely (5500, 5000, 4500, 4000, 3500, 3000, 2500, and 2000 Rpm), because for rotations below 2000 rpm the engine is not stable.

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Table-1. Chemical and physical properties of gasoline, biogas.

Properties	Gasoline	biogas
Molecular Formula	C_8H_{18}-C_7H_{16}	CH_4-55.6%
Density at 15 degrees C (kg/ m3)	720–775	1.11
Lower thermal value (kJ/kg)	43550 kJ/kg	17000 kJ/kg
Heat of vaporization (MJ/kg)	0.33	0.5
Stoichiometric A/F ratio	14.7	5.67
Research octane number	91	110
Auto ignition temperature (°C)	257	650
Flame Speed (cm/s)	45	25
Vaporization temperature (°C)	20–200	42

Source:[18]

Table-2. Testing machine specifications.

Brand	Honda Revo
Machine	4 Steps, SOHC
Diameter x Step	50 x 49.5 mm
Cylinder Volume	97.1 (100 cm^3)
Compression Comparison	9.0 : 1
Power Max	7.3 ps at 8500 rpm
Max Torque	0.74 kgf.m at 5500 rpm
Cooler	air
Ignition	AC - CDI, magnetto
Transmission	4 . rotary type Speed
Oil capacity	0.7 liter

In research, the use of biogas and gasoline in the combustion chamber will affect the concentration of CO and CO_2, and also engine performance is measured by torque, power, and specific fuel consumption. To see that, experiments were carried out with the test scheme shown in Figure-1.

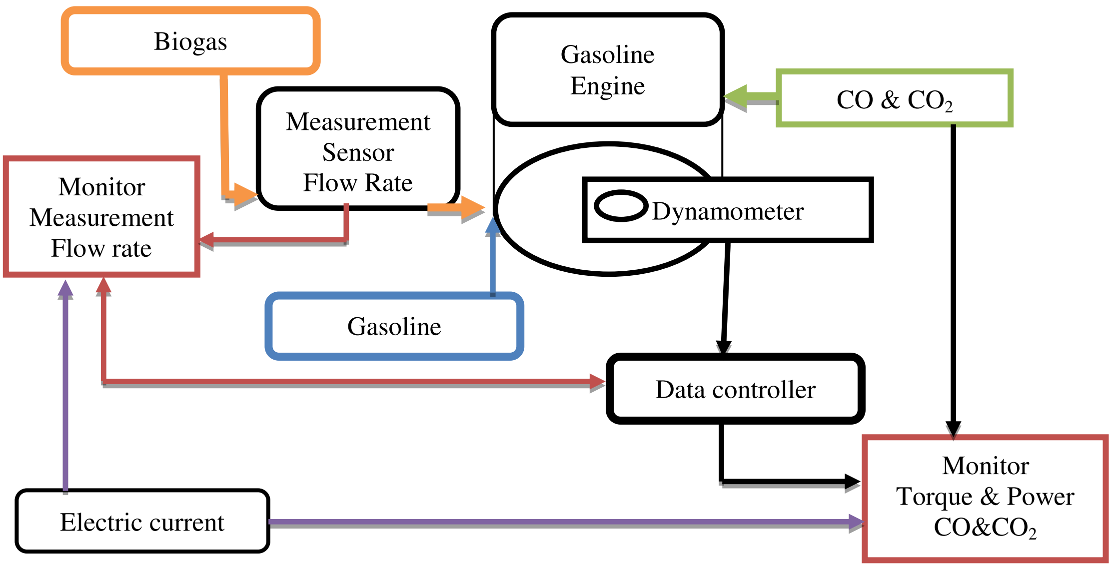

Figure-1. Schematic view of the experimental setup.

RESULTS AND DISCUSSIONS

Brake torque, brake power, and Brake-specific fuel consumption (BSFC) are indicators to evaluate the performance of a machine. Engine performance testing is carried out on variations in engine speed with the full open throttle testing method, namely the highest engine speed is 5500 rpm with added braking load until the engine speed reaches 2000 rpm. Torque results from gasoline and biogas mixtures with variations in flow rates can be seen in Figure-2. Engine brake torque tends to increase with each additional engine load at a certain engine speed. At high loading up to 2500 rpm engine speed, B3 is seen to increase significantly compared to B1, B2, and G, due to the higher turbulent flow into the combustion chamber as the load increases and the engine speed decreases, the addition of temperature makes biogas combustion more stable [20]. When gaseous fuel is used as the fuel mixture, the volumetric efficiency and power are significantly reduced since the biogas mixture occupies more of the combustion chamber volume [21].

Brake power with gasoline and biogas mixture can be seen in Figure-3, the test results show that the use of gasoline is higher than that of a mixture of gasoline and biogas at an engine speed of 4500 - 3000 rpm, the difference is more significant. The study was carried out without AFR settings so that it did not regulate complete combustion at every engine load and engine power requirements more than meet for low emissions [22].

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Mixed gasoline and biogas fuel requires an earlier ignition time and requires a higher temperature, this is because the combustion process for biogas fuel is slower than gasoline fuel [18]. At high engine loads up to 2500 rpm for a mixture of gasoline and biogas, it can be seen that the engine brake power has increased and for gasoline, it has decreased, due to the propagation speed of the biogas flame increasing exponentially with increasing temperature [23], [24]. At each flow rate, there is no significant difference in the increase in engine brake power from all variations, there is a slight increase in the B3 flow rate, so the greater the flow rate the greater the brake power produced [25].

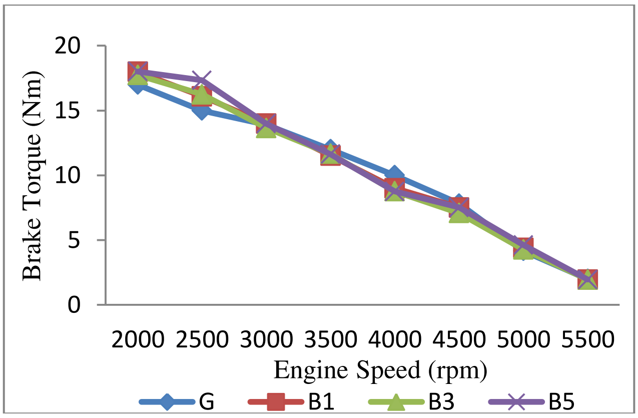

Figure-2. Brake torque to engine speed.

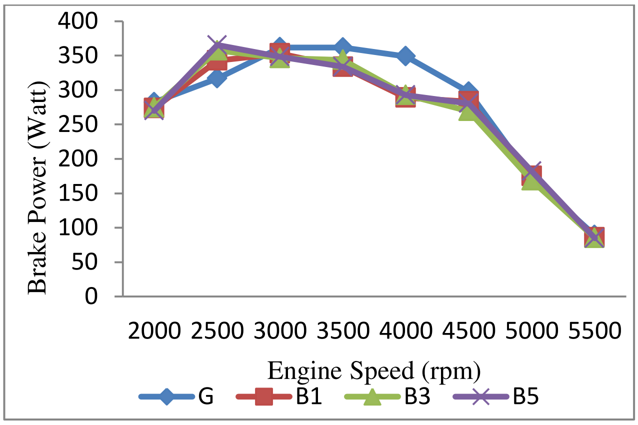

Figure-3. Brake power to engine speed.

Brake-specific fuel consumption (BSFC) in this study can be seen in Figure-4. BSFC can be seen as a parameter to show how effective a power generation system is to convert a certain amount of fuel into mechanical energy. BSFC is affected by the amount of fuel used per unit of time and the power that the engine is capable of producing [26]. The greater the power that can be generated by the motor with a small amount of fuel used, it will produce the smaller the specific fuel consumption. The BSFC of biogas fuel is lower than gasoline, especially for B3, this is because biogas fuel which has a gas phase is easier to burn than gasoline, this is because gasoline has to go through an atomization process to burn, so more fuel is needed because not all gasoline fuels can burn completely, while biogas does not require the fogging process it can burn completely so it takes less fuel [19]. The increase in load and engine speed causes a complete combustion process and results in better specific fuel consumption [25].

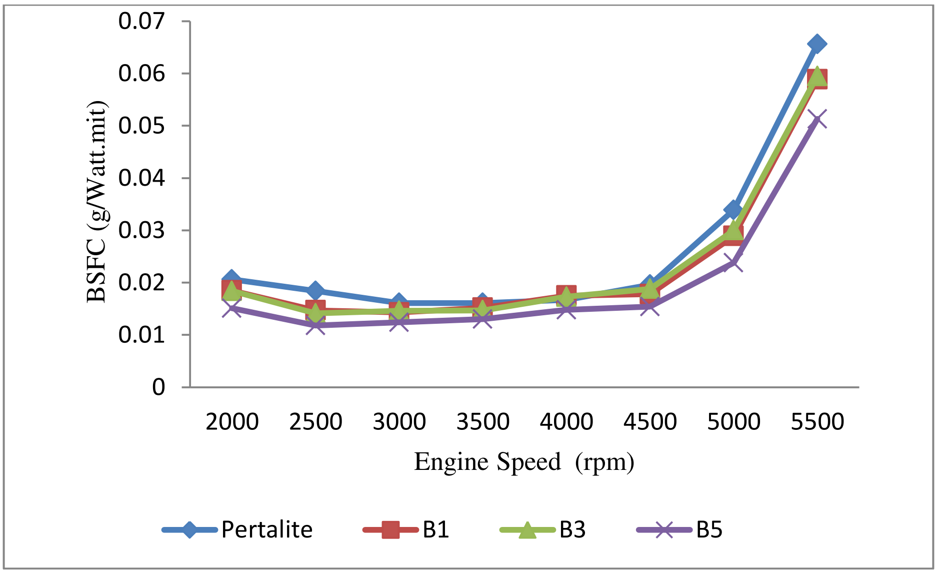

Figure-4. BSFC to engine speed.

In this study, exhaust emissions are discussed using CO and CO_2 numbers. It should be noted that carbon monoxide in exhaust gases is produced by incomplete combustion in the combustion chamber due to a lack of oxygen in the air-fuel mixture. The CO concentrations in exhaust gases for all engine loads and speeds are shown in

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Figa Figure-5. The results of the study show that there is a decrease in CO gasoline by 0.06% and B3 by 0.02% at the highest load, so gasoline fuel is higher than a mixture of gasoline and biogas, this is because the inertia of biogas is less than gasoline, this reduction occurs because they form a more homogeneous mixture with air. Regardless of the throttle situation, CO levels across all fuel used follow a downward trend with increasing load. When the graph is evaluated, the CO content decreases at all loads with the addition of biogas, especially at the B3 flow rate. In addition, because biogas has a large number of carbon atoms, a decrease in the level of CO emission is observed using biogas [27]. CO_2 is the most important gas causing the greenhouse effect which is generally produced from burning fossil fuels for transportation. The results of CO_2emissions can be seen in Figure-6, CO_2 mission will in increase as the rate of full combustion reaction increases as the temperature in the cylinder increases. Since engine load is also a factor increasing the temperature in the cylinders, CO_2 levels increase with gasoline consumption as engine load increases [27]. The difference in CO_2 content in the use of gasoline and biogas mixtures, the graph shows that gasoline CO_2 reaches 15.77% while for biogas mixed fuels it is in the range of 10.85% at the highest loading.

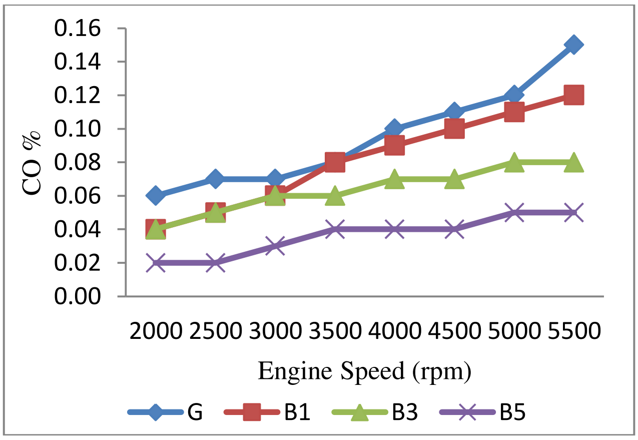

Figure-5. CO emission to engine speed.

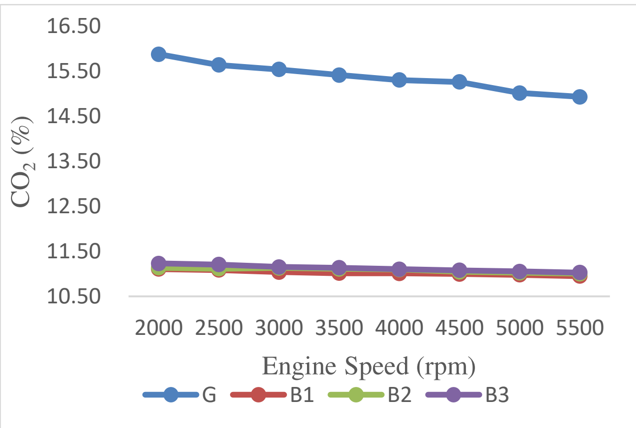

Figure-6. CO_2 emission to engine speed.

CONCLUSIONS

In the use of gasoline and gasoline–biogas mixtures with variations in the amount of biogas flow rate, the engine performance fluctuates for brake torque and brake power. At higher loading, the torque and brake power from the biogas mixture increase at 2500 rpm engine speed, and the brake power reaches 365.43 Watt on B3 and 316.87 Watt on gasoline. BSFC at the highest loading of gasoline is 0.0206 g/Watt.minute and B3 0.0151 g/Watt.minute so for BSFC the use of B3 is more effective. The CO and CO_2 emissions of gasoline fuel are higher than that of gasoline-biogas mixture fuels, CO gasoline 0.06% and CO B3 0.02%, CO_2 gasoline 15.77%, and CO_2 B3 10.85 %.

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