Performance Gasoline Generator Engine Fueled Liquid Petroleum Gas

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Abstract The government has now taken a policy to replace the use of fossil fuel oil, such as gasoline and petroleum diesel, into gas fuel. A converter kit and the modification of air filter are used to flow LPG (Liquid Petroleum Gas) into a generator. In this experiment, a three kg gas cylinder is used as fuel to run a gasoline generator engine of EG 1000 N S Type which is produced by Honda. The engine has a specification to generated power of 220 volts with 4.1 A outputs and 0.9kVA (720 watts) when operated using Gasoline fuel. The electricity produced during the operation of the generator engine is 680-700 watt when fueled with LPG. It was found that the generator engine fueled with LPG contributes to lower emissions which are still following Indonesian government regulation standards with a threshold value of CO and nitrogen oxide less than 500 mg/NM³ and 400/NM³, respectively.

1. Introduction

Indonesian law No. 30/2007 concerning Energy states that energy management which includes the supply, utilization, and operation must be carried out in a sustainable, rational, optimal, and integrated manner, to deliver added value to the economy of the nation of the Republic of Indonesia. Energy supply, utilization, and exploitation carried out continuously to improve people's welfare, in its implementation, must be in harmony, harmony, and balanced with environmental functions [1]. Furthermore, in Government Regulation No. 79 of 2014 concerning the National Energy Policy (KEN), among others, it is stated that the role of petroleum in 2025 is less than 25% and in 2050 to be less than 20%, whereas in 2025 the role of natural gas is at least 22% and in in 2050 at least 24% [2]. The level of fuel consumption (fuel) in Indonesia until 2015 still shows an increase in line with an increase in population and per capita income, with a value of 1,229 thousand bopd (barrels of oil per day). But this is not supported by domestic fuel production from 2010 to 2015 relatively unchanged, which amounted to 681 thousand bopd. Thus, a shortfall of 548 bopd, or around 45%, must be imported from abroad [3]. The impact of the use of fossil fuel oil impacts in increasing global warming and climate change, with all associated effects that threaten the life and preservation of the earth. In order to follow up on the Bali Action Plan agreement on the 13th Conferences of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCC) and the results of COP-15 in Copenhagen and COP-16 in Cancun, as well as meeting the commitments of the Indonesian government in the G-meeting 20 in Pittsburg in 2010, the Government of Indonesia submitted Intended Nationally Determine Contribution (INDC) to UNFCC, where Indonesia promised...
to reduce greenhouse gas (GHG) emissions by 26% compared to Business as Usual, and in addition to 41% with international assistance in 2020. In this situation, Presidential Regulation Number 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emission Reductions has been issued [4].

At the 21st UNFCC meeting in December 2015, the Paris Agreement was agreed which stated that the increase in global temperature must be controlled to less than 2 °C compared to the average temperature before the industrialization era (1880), where this agreement applies to all countries and is binding legally with the principle of Common But Differentiated Responsibilities (CBDR). To note, in the middle of 2016, the increase in the earth's temperature has reached around 1.3 °C compared to 1880. If the temperature reduction is targeted at 1.5 °C, the GHG emissions that must be reduced are around 40 Gigatons in 2030 [5]. Basically, the business can be divided into two namely energy conservation efforts and energy efficiency improvement. One way that can be taken on a smaller scale is to convert the use of gasoline-fueled engines to gas-fueled [6]. The implementation of this conversion system will certainly be appropriate when considering the level of fuel consumption, energy conversion efficiency, economic value, ease of obtaining fuel, and emissions produced. The use of gasoline-fueled engines in small traders, generally as electricity generators, and engines in fishing boats, is still quite common in Indonesia. The government currently has a program to replace the use of fuel oil into gas fuel on vehicle engines and fishing boats. However, to do this conversion requires a set of conversion tools called a converter kit, the price of which is relatively expensive because it is imported from abroad. To overcome this, it is necessary to strive to procure converter kits in domestic production, especially those whose designs are simple and inexpensive but to meet safety requirements.

Converter kit is a term used for a set of tools used to convert an oil-fueled engine to a gas-fueled one, without having to replace the engine [7]. Basically the converter kit is divided into two types, namely for alternating fuel use (bifuel, on a gasoline engine), and the use of fuel simultaneously (dual fuel, on a diesel engine). Each type is divided into conventional systems and injection systems. In general, conventional system converter kits consist of fuel delivery systems, solenoid valves, pressure gauges, pressure regulators and gas vaporizers, mixers, electronic circuits, and gas tanks [8]. The use of converter kits on gasoline engines is more popular than diesel engines because the economic value obtained is greater than that of diesel engine converter kits. In this research, the pressure regulator component of a conventional gasoline engine converter kit will be converted using LPG gas. This component selection is because, for other components can be purchased easily on the market. Another reason is that many of the pressure regulators on the market cannot work stably, have gas leaks, are difficult to operate, and the price is relatively expensive [9].

Figure 1. Experiment Running Generator EG 1000 N LPG (Liquid Petroleum Gas) with Converter Kit.
2. Experimental Method

2.1 Experimental Apparatus

The Generator Specification are listed as shown in Table 1.

| Table 1. The Specification of Generator Engine EG 1000 N S Type. |
|---------------------------------------------------------------|
| Description code    | EEGD          |
| Length              | 376 mm       |
| Width               | 301 mm       |
| Height              | 430 mm       |
| Dry Mass (Weight)   | 22,6 kg      |
| Fuel                | Gasoline     |
| Model               | EG 1000 N    |
| Type                | S            |
| Rated Voltage       | 220 V        |
| Rate Ampere         | 4,1 A        |
| Rated Output        | 0.9KVA       |
| Max Output          | 1,0 KVA      |

2.2 Problem Formulation

To perform the analysis, several parameters are used, and they are defined and formulated. The performance of the LPG fuel analyzed using the electric output power, efficiency, and specific fuel consumption. The output power $P_E$ (Watt) of the Generator engine is calculated by using the following equation

$$P_E = V \times I$$ (1)

Where $V$ [Volt] and $I$ [Ampere] are voltage and current of the electricity resulted from the generator, respectively. The brake thermal efficiency is defined as electric power divided by total energy input to the Generator engine. For the Generator engine run in Gasoline mode, it is calculated by

$$\eta = \frac{P_E}{m_{gasoline} \times H_{gasoline}}$$ (2)

where, $m$ [kg/s], $m'$ [kg/s], and $H$ [kJ/kg] are the mass flow rate of gasoline, flow rate of the LPG and the LPG value, respectively. The specific fuel consumption $sfc [g/kWh]$ is a comparison of gasoline consumption to useful energy. It can be viewed as how many grams of the Gasoline is needed to produce 1 kWh of electric power. For the Generator engine run in Gasoline, it can be calculated as follows.

$$sfc = \frac{m_{gasoline}}{P_E} \times 10^3$$ (3)

While for the Generator engine run in the dual-fuel mode it is defined as follows.

$$sfc = \frac{m_{gasoline} + m_{LPG}}{P_E} \times 10^3$$ (4)

In the analysis, the Gasoline energy ratio (ber) will be analyzed by using the ratio of energy input from LPG to the total energy input as follows.
Using the above-formulated parameters, the performance of the generator engine when it operated on pure Gasoline and LPG will be analyzed.

3. Result and Discussion

3.1 Petroleum Power

The output power as a function of engine load is shown in figure 2 and figure 3. The figures shown that the output power gas from the LPG 3 kg cylinder using converter kit was running well. The total output, when fueled by gasoline and LPG of 3 kg cylinder, is almost the same. The LPG contributes to a maximum power of 787 Watt, while the gasoline fuel produced 790 Watt.

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ber = \frac{m_{LPG} \times H_{LPG}}{P_E \times m_{Gasoline} \times H_{Gasoline} + m_{LPG} \times H_{LPG}}
\] (5)

Figure 2. The output of power generation using LPG.

Figure 3. The output of power generation using Gasoline fuel.
3.2 Thermal Efficiency
In this Experiment thermal efficiency is needed, especially for Gasoline process with a maximum temperature of 25 degrees Celsius, the range starts from 25-28 degrees Celsius, while the temperature LPG stable 28 degrees Celsius, to be used to run the generator requires a temperature gas 25-29 degrees celsius.

3.3 Synth Gas and LPG Gas Emission
The exhaust emission from the output generator using LPG 3 kg is shown in Table 2. Meanwhile, the exhaust emission from the output generator using pure gasoline is shown in Table 3.

Table 2. Exhaust Gas Emission Generator EG 1000 N, Regulation Of the Minister Environment and Forestry Republik of Indonesia No.p.15/MenLHK/SetJend/KUM.1/4/2019

|                  | Result     | Standard |
|------------------|------------|----------|
| Hidro Carbon     | 30 ppm     | 200 ppm  |
| Ambient Temperature | 27°C      | -        |
| Carbon Monoxide  | 55mg/NM³   | 500 mg/NM³ |
| Nitrogen Oksida  | 50 mg/NM³  | 400 mg/NM³ |
| Oksigen          | 0,9        | -        |
| HidrogenSulfida  |            |          |

Table 3. Exhaust Gas Emission Generator EG 1000 N, Regulation Of the Minister Environment and Forestry Republik of Indonesia No.p.15/MenLHK/SetJend/KUM.1/4/2019

|                  | Result     | Standard |
|------------------|------------|----------|
| Hidro Carbon     | 99 ppm     | 200 ppm  |
| Ambient Temperature | 27°C      | -        |
| Carbon Monoxide  | 59 mg/NM³  | 500 mg/NM³ |
| Nitrogen Oksida  | 50 mg/NM³  | 400 mg/NM³ |
| Oksigen          | 0,9        | -        |
| HidrogenSulfida  |            |          |

The exhaust gas produced using the Portable Combustion Analyzer, the emission gas from the generator set that uses LPG not different from the exhaust from gasoline fuel. A hydrocarbon that does not burn when using 3 kg LPG gas has a lower value, so banking is perfect when seen from the hydrocarbon value using 3 kg LPG of 20 ppm.

4. Conclusion and recommendation
1. With the modification of the air filter to make a gas path through a converter kit using an EG 1000 N generator, it is very feasible to use because the maximum value of the energy required is the same as the value generated using gasoline fuel.
2. For the amount of exhaust emissions are still by Indonesian government regulation standards with a threshold value of CO<500 mg/NM³nitrogen oxide< 400/NM³.
3. By using a Kit converter to regulate the flow rate of gas to the generator it is possible to be used for areas that have not been electrified, agricultural land and plantations and is also very good for fishermen to replace fuel oil.
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