**The Effect of Lpg Gas Fuel on The Performance of The Gx 390 Combustion Motor**

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**Abstracts** - Testing the internal combustion engine GX 390 with LPG (Liquefied Petroleum Gas) fuel has been conducted to evaluate the performance, efficiency, and emissions of the engine. The internal combustion engine demonstrated stable and consistent performance during testing with LPG fuel. Engine RPM and torque reached expected values, indicating that the engine can operate efficiently under various loads. The use of LPG fuel appeared efficient, with relatively low fuel consumption compared to conventional fuels such as gasoline or diesel. The engine’s compression ratio and thermal efficiency showed optimal energy utilization. Emissions from the internal combustion engine using LPG fuel were extremely low, aligning with stringent environmental standards. Levels of CO (carbon monoxide), HC (hydrocarbons), CO₂ (carbon dioxide), and NOx (oxides of nitrogen) emissions were below the maximum limits set, demonstrating that the engine has a clean and efficient combustion system.

**Keywords:** Internal Combustion Engine GX 390, LPG Emissions, LPG Performance

**INTRODUCTION**

The use of fuel oil-based energy in Indonesia is still dominated by fossil sources, especially in the transportation and multipurpose machinery sectors. This dependence raises two main issues: the reduction of fossil energy reserves and the increase in greenhouse gas emissions that contribute to global warming [1]. The rapid growth of the transportation sector in line with economic development has significantly increased fuel consumption, triggering emissions of pollutants such as carbon dioxide (CO₂), nitrogen oxide (NOₓ), carbon monoxide (CO), hydrocarbons (HC), and particulate matter [2–4].

Various types of fuel, such as Premium, Pertalite, Pertamax, and Pertamax Turbo, have different Research Octane Number (RON) values but still produce emissions that have a negative impact on the environment [5]. Therefore, the search for alternative fuels that are more environmentally friendly is a priority. One of the candidates that is widely studied is Liquefied Petroleum Gas (LPG), a mixture of propane (C₃H₈) and butane (C₄H₁₀), which has a high calorific value, a cleaner combustion process, and a lower carbon content than conventional fuels [6–8].

Previous studies have shown that the use of LPG in internal combustion engines can significantly reduce CO₂ and particulate emissions [9–11]. However, burning LPG at high temperatures can increase NOₓ formation, while imperfect combustion has the potential to produce CO and HC [12–14]. Previous research has generally focused on LPG applications in light vehicles or small motorcycles, often with modified engines or capacities under 150 cc [15–17].

The research gap can be seen in the lack of studies on the use of LPG in GX 390 (±389 cc) type multipurpose gasoline engines, which are widely applied in the agricultural, marine, and small industry sectors. The operating characteristics of these engines, such as the need for stable power at constant loads, have the potential to affect the LPG combustion response differently than vehicle engines. In addition, the relationship between performance, fuel efficiency, and emission profiles at various engine revolutions has not been widely analyzed simultaneously under controlled test conditions.

Therefore, this study aims to:

1. Evaluate the effect of LPG on the power, torque, fuel consumption, and exhaust emissions of the GX 390 engine at four rev levels (2000, 3000, 4000, and 5000 rpm) under controlled laboratory conditions.
2. Compare the performance of LPG with gasoline (Pertalite) as a reference.
3. Provide an integrated analysis of performance and emissions to assess the feasibility of LPG as an efficient and environmentally friendly alternative fuel for small-scale multipurpose engines.

**METHODOLOGY**

**Research Methods**

The research method is carried out systematically through several stages, based on test procedures for accurate data analysis. The following is the implementation of the research method:



Good Condition

Not

Yes

Test Implementation

RPM, Torque & Temperature

Conclusion

Data Analysis

Data Collection

Machine Setup & Setting

Studi Literature

**Time and Place**

The scientific paper research entitled, "The Effect of LPG Gas Fuel on the Performance of the GX 390 Combustion Motor" was carried out on June 16, 2025 at the Mechanical Engineering Study Program, University of Muhammadiyah Malang, with the aim of evaluating the influence of LPG fuel on the power, torque, fuel consumption, and exhaust emissions of the GX 390 engine under controlled laboratory conditions.

**Research Variables**

The research variable is a concept in the study of the Effect of LPG Gas Fuel on the Performance of the GX 390" Combustion Motorcycle, this concept is something that must be observed and also researched to analyze the energy density of the performance of the BBG combustion motor using the GX 390 Combustion Motor manufactured by Honda engine manufacturer with a cylinder volume of 100cc, 4 steps with LPG gas fuel. The energy density performance test process on the rotation speed of the combustion motor used includes: 2000 RPM, 3000 RPM, 4000 RPM and 5000 RPM. The rotational speed is then accumulated at the time every minute to determine the energy density of the combustion motor while operating. The process of burning fuel that occurs in the combustion motor while operating, results in exhaust gas emissions and an increase in heat temperature.

The research variables in this study included the power, torque, fuel consumption, and exhaust emissions of the LPG-fueled GX 390 engine which was tested at four rev levels (2000, 3000, 4000, and 5000 rpm) to analyze the relationship between rev speed, energy density, combustion temperature, and the resulting emission profile.

**Test Equipment**

This study uses an experimental method on the Honda GX 390 multipurpose gasoline engine fueled by LPG. The engine has a four-stroke, OHV, single-cylinder configuration, cylinder volume ±389 cc, maximum power of 8.7 kW (11.7 HP) at 3600 rpm, compression ratio of 8.2:1, and maximum torque of 26.5 N·m at 2500 rpm.

LPG fuel is stored in a tube connected to the engine through a regulator hose to regulate the pressure and flow rate of the gas, then flowed to the LPG converter which functions as a link as well as a fuel supply regulator to the carburetor. The supporting equipment consists of a stopwatch to measure the duration of fuel consumption, a digital tachometer to monitor the rotation speed of the crankshaft, an infrared thermometer to measure engine temperature and exhaust gases, and a dynotest to record power, torque, engine revs, speed, air–fuel ratio, and operating time.

The preparation process includes installing a vacuum nipple on the heat insulator to activate the vacuum valve, installing the LPG nipple near the carburetor valve as a gas fuel inlet, and connecting the hose from the vacuum nipple to the vacuum valve and from the LPG nipple to the LPG output in the vacuum valve.

Before operation, the converter kit is set to factory specifications, the regulator is opened half a turn, the LPG valve is activated, the throttle is opened half opening, and the manual starter is pulled twice to ensure the gas supply enters the combustion chamber. The engine is then started with a switch in the ON position, the throttle is in the closed or slightly open position, and the starter is pulled until the engine reaches a stable idle state. Tests were conducted at four engine rev levels (2000, 3000, 4000, and 5000 rpm) with controlled throttle setting and rotation stability monitoring using a digital tachometer, followed by recording of performance parameters, fuel consumption, and exhaust emissions

**Results and Discussion**

Analysis of the use of LPG (Liquefied Petroleum Gas) gas on the performance of the GX 390 Combustion Motor with a deep combustion system. The main focus of the study is to identify the performance of combustion motors with LPG gas fuel connected to combustion motor engines. The use of LPG gas fuel in the GX 390 combustion engine has several significant influences on engine performance. Here is a further analysis of these influences.

**Performance Produced by LPG BBG**

Performance The LPG-fueled GX 390 engine is evaluated based on output power, torque, engine temperature, and exhaust gas temperature at four rev levels, namely 2000, 3000, 4000, and 5000 rpm. Each test is repeated three times to obtain a representative average.

The results show that the power increases consistently as the revs increase, with a maximum value of 10.6 HP at 5000 rpm. A peak torque of 26 N·m is reached at 3000 rpm, then decreases at higher revs, as is typical of medium-sized gasoline engines. The engine temperature increased from about 76°C at 2000 rpm to 105°C at 5000 rpm, while the exhaust gas temperature rose from ±310°C to ±415°C. This increase reflects an increase in thermal load due to higher combustion intensity at fast spins. Small fluctuations between test iterations are thought to be caused by differences in engine initial temperature, variations in fuel flow, or throttle response. Overall, the use of LPG results in stable performance, with optimal torque at medium revs and maximum power at high revs, making it suitable for applications that require efficiency.

**Fuel LPG Consumption**

Fuel consumption is measured in kg/h and km/l at each engine rev level. The test results show a trend of increasing LPG consumption as the round increases. At 2000 rpm, the average consumption was recorded at ±0.85 kg/h (about 15.3 km/l), while at 5000 rpm it increased to ±1.80 kg/h (about 18.0 km/l).

Interestingly, although the amount of LPG used per hour is greater at high revs, mileage efficiency (km/l) actually increases. This indicates that at high rotational speeds, the air-fuel ratio is close to optimal conditions so that combustion is more efficient. Factors such as increased airflow in the carburetor, higher cylinder pressure, and flame stability all contribute to this increase in efficiency. Thus, the use of LPG at medium to high loads can provide good energy efficiency without sacrificing engine performance.

**Exhaust Gas Emissions**

Exhaust emissions testing on the LPG-fueled GX 390 engine was carried out for four main parameters, namely carbon monoxide (CO), non-combustible hydrocarbons (HC), carbon dioxide (CO₂), and nitrogen oxide (NOₓ). The results showed that CO increased from about 1803 ppm at 2000 rpm to ±2400 ppm at 5000 rpm. This increase indicates a tendency for a richer air–fuel *mixture* at high revs.

HC increased from ±90 ppm to ±120 ppm as the round increased. This condition is likely caused by a reduction in the burning time at high speeds, so that some of the fuel does not burn completely. CO₂ rises gradually from ±66 ppm at 2000 rpm to ±72 ppm at 5000 rpm, reflecting relatively efficient combustion, although it still produces the main greenhouse gases.

NOₓ experienced a significant increase from ±160 ppm to ±280 ppm at the highest round, in line with an increase in peak temperatures in the combustion chamber that accelerated the reaction of the formation of this compound. These findings underscore the need for emission control technologies, such as *catalytic converters* or *exhaust gas recirculation* (EGR), to suppress NOₓ and CO, especially at high rev operations.

**Environmental Test Parameters**

In the testing of combustion engines that use LPG gas fuel, factors such as air pressure, room temperature, and humidity play a crucial role in determining engine performance and efficiency. Optimal air pressure ensures efficient combustion, while the right room temperature affects the viscosity of fuel and air. In addition, the appropriate air humidity helps to maintain the stability of the combustion, avoiding imperfect or over-fast combustion. The parameters of the environmental test are as follows:

Environmental test parameters have a direct relationship with the test of a combustion motor using LPG (Liquefied Petroleum Gas) fuel. In the context of the LPG BBG (Fuel Gas) combustion motor test, understanding how these parameters affect engine performance is critical to ensure that the engine operates optimally and produces emissions that comply with environmental standards. Testing in a variety of environmental conditions helps determine the operational limitations of the machine and ensures that the machine can function properly in a variety of weather and environmental conditions.

**Comparison of Combustion Motor Performance Values**

The value of the analysis results is quoted from the average value of the test results presented in the form of a graph. The graph shows the comparative value of the RPM used with the test value. The following is a graph of the results of the comparison of the performance value of the GX 390 combustion engine:

1600

1400

1200

1000

800

600

400

200

0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Power (HP) | Torsi (N.m) | Machine Temperature | Exhaust Temperature |
| RPM 5000 | 10,6 | 22 | 105 | 415 |
| RPM 4000 | 9,8 | 24 | 96 | 380 |
| RPM 3000 | 8,4 | 26 | 86 | 340 |
| RPM 2000 | 6,1 | 25 | 76 | 310 |

**Figure 3.** 1 GX 390 Performance Graph Data

The graph shows the performance of the internal combustion engine at various RPMs (Revolutions Per Minute) by including power (in HP), torque (in N.m), engine temperature, and exhaust temperature. Increased RPM, power and torque also increase which indicates that the engine produces more power and rotary power at higher speeds. Engine temperatures tend to increase as RPM increases, but they remain within relatively low limits (100-150°C for modern engines). The exhaust temperature increases more significantly as the RPM increases, reaching over 400°C at 5000 RPM. This indicates that the fuel burn becomes more intense at higher speeds. At higher RPMs, the engine may work more efficiently in terms of fuel burn, which is indicated by the increased exhaust temperature. However, it should be noted that temperatures that are too high can lead to increased exhaust emissions and potential damage to engine components. Power increases as RPM increases, torque also increases to a certain RPM before it starts to decrease. This indicates that the engine has an optimal balance of power and torque at multiple rotational speeds.

**Comparison of LPG Fuel Consumption Value**

180

160

140

120

100

80

60

40

20

0

|  |  |  |  |
| --- | --- | --- | --- |
|  | Consumption Kg/h | Consumption Km/l | Speed Km/h |
| RPM 5000 | 1,796 | 3,23 | 60 |
| RPM 4000 | 1,5 | 2,77 | 48 |
| RPM 3000 | 1,196 | 2,21 | 36 |
| RPM 2000 | 0,85 | 1,57 | 24,01 |

**Figure 3. 2** LPGG Fuel Consumption Comparison Chart

The graph data displays fuel consumption, fuel efficiency (in km/l), and vehicle speed at various RPMs (Revolutions Per Minute). Overall, this data provides an overview of how fuel efficiency and fuel consumption change as vehicle speed and engine RPM change

**Comparison of Exhaust Emission Values**

9000

8000

7000

6000

5000

4000

3000

2000

1000

0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | CO Emissions | HC Emissions | CO2 emissions | Nox Emissions |
| RPM 5000 | 2400 | 120 | 72 | 280 |
| RPM 4000 | 2196 | 105 | 70 | 250 |
| RPM 3000 | 2000 | 95 | 68 | 210 |
| RPM 2000 | 1803 | 90 | 66 | 160 |

**Figure 3.** 3 LPG Exhaust Gas Emissions Graph

From the graph data above, CO and NOx emissions increase significantly along with the increase in RPM. This can be caused by more incomplete combustion at high speeds. CO₂ emissions are also increasing, but not as fast as CO and NOx. HC emissions show a more complex pattern; starting from 90 ppm at 2000 RPM to 120.3333 ppm at 2400 RPM, then stabilizing or decreasing slightly. An increase in RPM is associated with an increase in harmful gas emissions, except for HC which does not show a linear increase. It is possible that the engine is subjected to different operating conditions at high speeds, which affects the type and amount of emissions generated.

**Comparison of LPG and Pertalite Exhaust Gas Emissions**

Based on the results of the comparison test of LPG and Pertalite on the GX 390 engine, LPG fuel produces lower CO but higher HC and NOx than Pertalite, with more efficient hourly consumption but more wasteful consumption per kilometer, so the fuel selection must consider the needs of performance and mileage efficiency.

700

600

500

400

300

200

100

0

|  |  |  |
| --- | --- | --- |
|  | LPG | Perthalite |
| Nox (ppm) | 280 | 334 |
| HC (ppm) | 120 | 137 |
| CO (ppm) | 71,8 | 61 |
| Consumption Km/l | 17,91 | 22,55 |
| Consumption Kg/l | 1,81 | 1,97 |
| Torsi (Nm) | 22 | 23,1 |
| Power (HP) | 10,7 | 11,8 |

**Figure 3.** 4 Power Efficiency of GX 390 Motor

Power Efficiency Combustion motors with LPG fuel show better power efficiency with higher power and torque. Fuel Consumption: Although fuel consumption per hour is lower with LPG, consumption per kilometer is higher, which may not be advantageous for long-distance travel. The exhaust emissions of LPG gas combustion engines produce less CO but more HC and NOx compared to pertalite gasoline engines.

**CONCLUSION**

Combustion motor tests with LPG (Liquefied Petroleum Gas) fuel have been carried out to evaluate the performance, efficiency, and emissions of the engine. The combustion motor showed stable and consistent performance during testing with LPG gas fuel. The engine rotational speed (RPM) and torque reach the expected values, indicating that the engine can operate efficiently at a wide range of loads. Internal combustion engine performance and RPM, including, torque, engine temperature, and exhaust temperature. Increased RPM leads to an increase in power and torque, as well as an increase in engine and exhaust temperature. The exhaust temperature increases more significantly, reaching over 400°C at 5000 RPM, indicating more intense fuel combustion. However, temperatures that are too high can increase exhaust emissions and potential engine damage. Power increases with RPM, while torque increases to a certain point before decreasing, indicating an optimal balance between power and torque. CO and NOx emissions increase significantly with increased RPM, due to more incomplete combustion. HC emissions show a complex pattern, starting to increase to RPM 2400 then stabilizing or decreasing. An increase in RPM is generally associated with an increase in hazardous gas emissions, except for HC. significant increase in CO and NOx emissions along with increased RPM, due to more imperfect combustion at high speeds. CO₂ emissions are also increasing, but not as fast as CO and NOx. HC emissions show a complex pattern, starting to increase to RPM 2400 then stabilizing or decreasing. An increase in RPM is associated with an increase in harmful gas emissions, except for HC. The engine may experience different operating conditions at high speeds, affecting the type and amount of emissions generated. The power efficiency of combustion motors with LPG fuel shows better efficiency with higher power and torque. Fuel consumption per hour is lower with LPG, but consumption per kilometer is higher, which may not be advantageous for long-distance travel. The exhaust emissions of LPG gas combustion engines produce less CO but more HC and NOx compared to pertalite gasoline engines.

**Suggestion**

The fuel consumption per kilometer of LPG gas is higher than that of pertalite gasoline. The use of LPG as an alternative fuel has the potential to reduce CO emissions and improve energy efficiency, but to reduce HC and NOx emissions, strategies such as air-to-fuel ratio optimization, ignition timing, or the addition of after-treatment systems such as catalytic converters compatible with LPG, as well as considering economic aspects of long-distance use.

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