International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 9 Issue 9 September - 2025, Pages: 37-42

The Performance Characteristics of Petrol and Liquefied Natural Gas in an Engine Test Bed using Versatile Data Acquisition System

Yeri Julius Eniyekedou[1*], Worgu Fortune[2] and Uchendu Imereoma Frank[3]

[1]Department of Mechanical Engineering, Niger Delta University, Nigeria
[2 and 3]Department of Mechanical Engineering, Rivers State University of Science and Technology, Rivers State, Nigeria
*Corresponding author: yemi.olisa@yahoo.com

ABSTRACT: *Different types of fuels such as gasoline and liquefied natural gas (LNG) exhibit varying performance characteristics when applied in thermal systems like furnace, boilers, internal combustion engines etc. This necessitate determining and comparing their performance metrics using the Versatile Digital Acquisition System (VDAS). The aim of this work was to apply VDAS to determine the performance characteristics of gasoline and LNG in an internal combustion engine test bed. A TD 200 four-stroke gasoline test engine (modified for the Tec-Equipment TD 200 small engine test bed), a hydraulic dynamometer, a dual carburettor and a VDAS were all used in the experimental configuration. Measured performance metrics included torque, power, air mass flow rate, brake mean pressure (BMEP), volumetric efficiency and exhaust gas temperature. The experimental results reveals that in contrast to gasoline, which produced 1876 W at lower rpm, LNG produced more power at higher speeds, peaking at 2,521 kW around 3800 rpm. At 2900 rpm, LNG's BMEP (5.28 bar) was higher than that of gasoline. While both fuels showed reduced efficiency at higher speeds, gasoline had a better volumetric efficiency (85.7% at 2300 rpm) than LNG (82.27% at the same speed). Using LNG as a fuel can result in a significant reduction in fuel consumption. The conclusion of the investigations showed that, altogether, LNG performs better than gasoline, making it the preferred choice for engine applications.*

Keywords: Break Power, Fuel consumption, Pressure, Performance metrics, Emission, Calorific value and Volumetric efficiency.

1. INTRODUCTION

A data acquisition system (DAS) is a system that includes sensors, measurement instruments, a computer and software for gathering data. DAS is used to collect, store, visualize and process data. This includes collecting the information required to understand electrical or physical phenomena. Environmental investigations, medical monitoring, industrial automation, scientific research, quality control, manufacturing and healthcare are just a few of the industries that employ DAS (Chapman, 2007) [3]. By offering data-driven insights, DAS systems can assist engineers in making well-informed decisions. Engineers can utilize DAS systems, for instance, to pinpoint system failures and spot patterns in parameters like temperature or pressure. For a number of uses, including real-time data capture, quick recording, analysis (calculate, chart, and export data) and user-friendly software; VDAS is a digital system that gathers and analyzes data from sensors and instruments (Briggs, 2020) [2].

Due to its easily accessible energy density and effective combustion qualities, gasoline is a crucial component of the majority of cars, motorcycles and small engine machinery. In an internal combustion engine, gasoline is primarily used as the fuel source for a "spark ignition" process, where it is combined with air, compressed inside the cylinder and ignited by a spark plug to generate power by expanding the combustion gases, which pushes the piston and ultimately drives the engine's rotation system (Chasos et al, 2021) [4].

An internal combustion engine's fuel performance would normally examine the effects of the various fuel characteristics, such as octane rating, calorific value, chemical composition, volatility and additives on important engine performance metrics, including power output, torque, brake mean effective pressure (BMEP), emissions levels, combustion stability under varied operating conditions, thermal efficiency and specific fuel consumption (Anderson, 2024) [1]. The following are also included: (1) the combustion analysis, which includes the flame propagation speed, or how fast the combustion wave moves through the cylinder and how long it takes for combustion to finish; (2) the emissions characteristics, which include the nitrogen oxides (NOx), particulates matter and unburned fuel (carbon monoxide and hydrocarbon).

Dond and Gulhane (2019) [5] looked reported how fuel type affected the state of internal combustion engines. The consequences of fuel types on energy, traffic, economy and the environment were all carefully and objectively investigated. The experiment made use of two identical passenger cars, one with a gas installation and the other running on gasoline. The results showed that although properly placed gasoline installations and LPG use have a significant impact on the economic and environmental elements of driving passenger cars, they have no appreciable impact on driving performance.

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 9 Issue 9 September - 2025, Pages: 37-42

Kanna et al. (2019) [6] investigated the performance of several fuels for internal combustion engines. The traditional fuels used are gasoline, diesel and compressed natural gas (CNG); the newer alternative fuels are biodiesel, ethanol, hydrogen and ethanol mixed with gasoline and diesel. These alternative fuels can extend the life of petroleum because of the availability of fuels like hydrogen and the ability to produce fuels like ethanol in response to needs and specifications. The efficiency of a gasoline machine is greatly influenced by its contraction rate. When the contraction rate is increased above 9, the gasoline machine's typical contraction rate falls between 6 and 9.3, then the likelihood of an eruption will rise.

In a research on data collection, Kholod et al. (2016) [7], asserted that DAS, using simple-to-integrate software like Visual Basic, improves measurement efficiency and reduces test costs. Unlike conventional and customary measures, this approach enables engineers to use graphical representation to meet their own goals. At a fraction of the cost and time, it is possible to test, measure and regulate up to 10 times the efficiency of a traditional measurement system.

2. METHODOLOGY

This section discusses the materials and method used to assess the performance characteristics of gasoline and LNG in internal combustion engines.

Materials

The materials that were used to perform this experiment are as follows:

i. VDAS
ii. Tec-Equipment TD 200 small engine test bed
iii. Tachometer
iv. A single-cylinder, four stroke spark-ignition test engine
v. Hydraulic dynamometer
vi. Dual Carburretor
vii. Stopwatch.
viii 3 kg cylinder

The specification of the engine test bed

The specification of the engine test bed is shown in Table 1

Table 1: Specifications for the Engine Test Bed.

Item	Specifications
Absolute maximum power	4.4 kW (6hp) at 4000 rpm.
Gas cylinder	4.5 kg, steel vessel pressure 30 bar
Net weight (with base plate)	20 kg
Tubes	Flexible plastic able to withstand 30 bar
Fuel type	Unleaded gasoline and LNG
Exhaust outlet	Normal 1BSP
Ignition system	Electric
Dimensions (when fitted to base plate)	Width 400 mm, height 400 mm, depth 300 mm
Bore	67 mm
Stroke/Crank radius	49 mm/24.5 mm
Oil type*	SAE20, SAE30 or Multigrade 10-30W
Engine capacity	172 cm^3

Compression ratio	8.5:1
Engine oil capacity	0.65 litres
LPG	2.74 kPa
Connecting rod length	85 mm
Fuel tank	Steel with vents and a filler cap

Experimental Setup and Procedure

The test engine, hydraulic dynamometer, blending chamber, engine control system, laminar air flow meter, fuel flow meter, and emission analyzer are the parts of the experimental setup (shown in Plate 1

The experimental procedure is as follows:

i) The test engine is connected to the engine test bed and module wires are fitted between the VDAS hub and the individual modules.

ii) the torque input and the air box pressure are adjusted to zero readings.

iii) The engine tank is either filled with petrol or alternatively the dual carburettor may be connected to a gas line from a gas cylinder.

iv) The engine is started and the operator can observe the real time readings and the calculated parameters.

v) The load on the engine can be adjusted to alter the speed, torque and power.

Plate 1: Experiment set up of the VDAS and the engine test bed

3. RESULTS AND DISCUSSIONS

This section discusses the findings from the laboratory experiment using VDAS to evaluate the performance metrics of gasoline and LNG in a four-stroke test engine. The energy content per unit volume was computed by dividing the heating values by the volumes of the LNG and gasoline in order to normalize the results. Consequently, energy output may be directly compared regardless of physical attributes.

Comparison of the Performance Characteristics of Gasoline and LNG

The parameters obtained from VDAS for gasoline and LNG are shown in Table 2

Table 2: Data obtained from VDAS for petrol and LNG

S/N	Fuel	Power (W)	Volumetric efficiency (%)	Air mass flow rate. (x10^{-3} kg/s)	Torque (N.m)	BMEP (bar)	Speed (rpm)	Exhaust gas temp (°C)
1	Petrol	1876	85.7	1.88	11.2	5.57	2300	499

2	LNG	1784	82.27	1.90	10.7	5.07	2300	500
3	Petrol	1989	77.2	2.21	10.1	5.32	2600	548
4	LNG	1983	73.87	2.04	9.6	5.06	2600	521
5	Petrol	1798	67.8	2.53	8.8	4.22	2900	563
6	LNG	2216	66.80	2.45	8.6	5.28	2900	552
7	Petrol	1698	62.1	2.81	8.1	3.65	3200	591
8	LNG	2311	60.91	2.78	7.9	4.96	3200	563
9	Petrol	1264	56.9	3.07	7.4	2.48	3500	596
10	LNG	2415	55.88	2.98	7.3	4.66	3500	575
11	Petrol	1032	52.4	3.21	6.8	1.87	3800	598
12	LNG	2521	51.62	3.1	6.7	4.5	3800	599

According to Table 2, which compares the performance of gasoline and LNG in a four-stroke engine at different operating conditions of speed (rpm), the torque and volumetric efficiency of gasoline fuel are higher than those of LNG at all speed conditions, while the brake power, BMEP and exhaust gas temperature values are generally higher for LNG than for gasoline.

The following analysis were done for comparing various performance characteristics:

i) Tongue developed by Petrol and LNG

The torque generated by the engine at various RPMs for both gasoline and LNG is displayed in Figure 1. The torque drops from the range of 11.2 to 6.8 Nm when the speed increases from 2300 to 3800 rpm, while gasoline performs relatively less. This suggests that gasoline often produces more torque at a lower speed of 2300 rpm. Furthermore, the plot of LNG at a lower speed of 2300 rpm indicates improved performance characteristics of LNG as a fuel, especially in terms of power delivery, as the torque spontaneously drops from 10.7 to 6.7 Nm while the load increases from 2300 to 3800 rpm continuously.

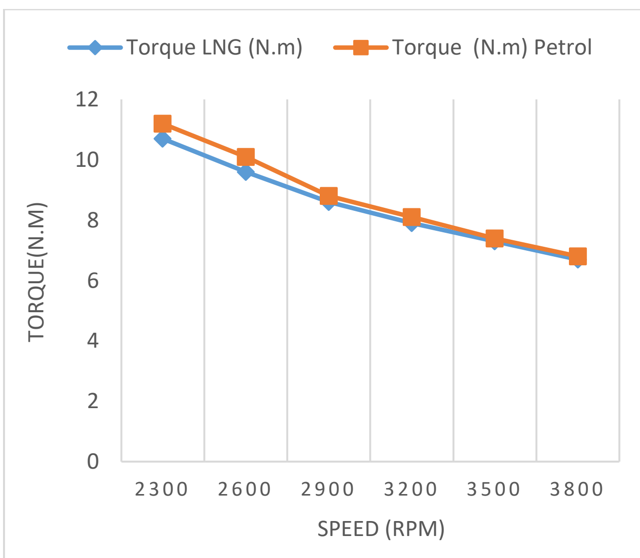

Figure 1: Torque Developed for Petrol and LNG

ii) Power Developed by Petrol and LNG

Figure 2 compares the power generated by an engine running on gasoline and LNG, i.e., the power output of an engine running on gasoline and LNG at a range of engine speeds between 2200 and 3800 rpm. The power output of gasoline begins around 2200 rpm slightly over 2000 W, peaks at about 2500 W near 2600 rpm, then gradually drops to less than 1500 W by 3800 rpm. This suggests that gasoline produces its most power at mid-range engine speeds and becomes less efficient as speed rises above this threshold. LNG power output, on the other hand, begins at about 2000 W and 2200 rpm, which is somewhat less than that of gasoline, but it gradually rises to surpass the peak of gasoline and reach nearly or slightly above 2500 W at 3800 rpm. The graph displays the performance characteristics, with LNG performing better at higher speeds and gasoline being more effective at mid-range speeds.

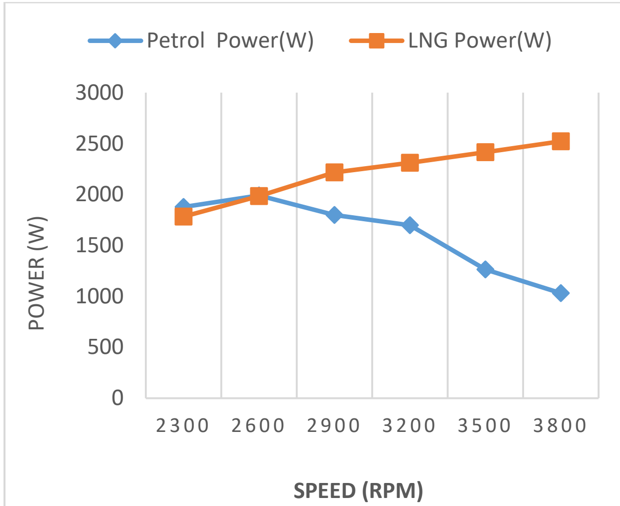

Figure 2. Power Developed by Petrol and LNG.

iii) BMEP Developed by Petrol and LNG

The comparison of the BMEP for engines running on gasoline and LNG at different engine speeds, ranging from 2300 to 3800 rpm is depicted in Figure 3. The BMEP for gasoline begins at 2300 rpm just above 5 bars and progressively drops to just below 3 bars at 3800 rpm. This suggests that at lower engine speeds, gasoline retains a comparatively high BMEP, which progressively decreases as speed rises. Petrol engines may be more efficient at lower to mid-range speeds, offering higher pressure and possibly better performance, according to the continuous drop. On the other hand, the BMEP for LNG drops more precipitously to just above 1 bar at 3800 rpm after beginning just below 4 bars at 2300 rpm. This greater decline suggests that when engine speed increases, BMEP for LNG engines decreases more significantly. LNG may be less effective than gasoline at sustaining pressure, particularly at higher rpm, as seen by the lower BMEP at higher speeds.

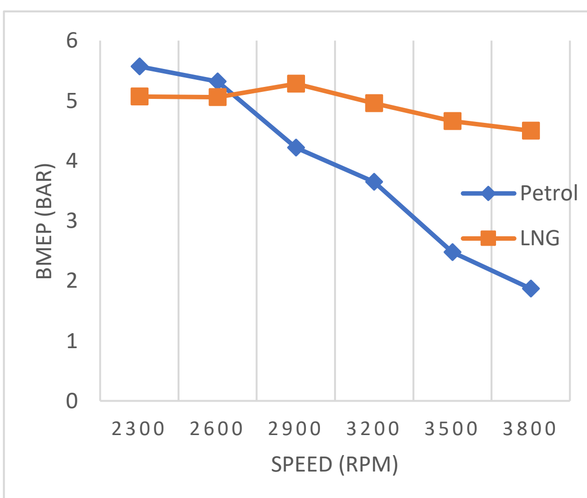

Figure 3: BMEP of Petrol and LNG

iv) Volumetric Efficiency of Petrol and LNG

The volumetric efficiency of the engine when gasoline and LNG were used is compared in Figure 4, which shows that at 2300 rpm, the engine's volumetric efficiency increases to 85.7% and 82.27%, respectively. It demonstrates that at most speeds, LNG's volumetric efficiency is lower than that of gasoline, falling between 2600 and 3800 rpm for both. These are explained by LNG's gaseous nature, which results in a less dense fuel-air mixture. This reduced efficiency at specific speeds points to difficulties in LNG air-fuel mixture optimization.

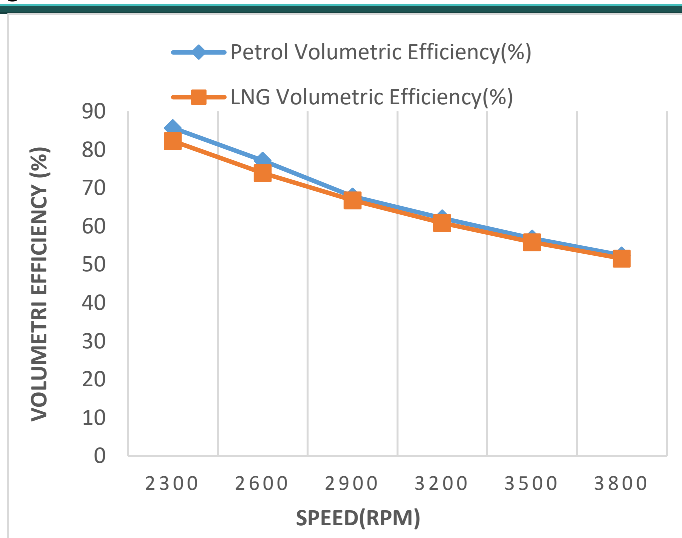

Figure 4: Volumetric Efficiency of Petrol and LNG

4. CONCLUSION

The extensive research on how well LNG operate in internal combustion engines (ICEs) has provided important new information on the fuel's properties and operational efficiency at different engine speeds. In terms of torque and power production, the investigation showed that LNG typically performs better than gasoline, especially at higher rpm, suggesting that it may be a more effective alternative fuel. According to the study, LNG generates greater exhaust temperatures, which helps explain why it is regarded as a greener alternative to conventional gasoline. The study's conclusions can be applied to improve engine designs and operating procedures that optimize LNG's advantages, especially with regard to fuel economy and emissions reduction.

5. REFERENCES

1. Anderson J. O. (2024): Technological innovations in the LNG sector: A review: Assessing Recent Advancements and Their Impact on LNG Production, Transportation and Usage. *World Journal of Advanced Research and Reviews*, *21*(1), 040–057.
2. Briggs, D. N. (2020): Hydrogen Internal Combustion Engines. *International Journal of Hydrogen Energy*, *45*(43), 23692–23703.
3. Chapman, K. S.: Performance, Efficiency and Emissions Characterization of Reciprocating Internal Combustion Engines Fueled with Hydrogen/Natural Gas Blends. Kansas State University Amar Patil, Research Associate, Kansas State University Final. Technical Report October 1, 2004 – June 20, 2007**.**
4. Chasos, C., Karagiorgis, G., & Christodoulou, C. (2014). Technical and Feasibility Analysis of Gasoline and Natural Gas Fuelled Vehicles. *AIMS Energy*, *2*(1), 71–88.
5. Dond, D. K. & Gulhane, N. P. (2020). Effect of Combustion Parameters on Performance, Combustion and Emission Characteristics of a Modified Small Single-Cylinder Diesel Engine. *International Journal of Recent Technology and Engineering (IJRTE)*, *8*(5), 622–630.
6. Kanna, I. V., Arulprakasajothi, M. & Eliyas, S. (2019). A Detailed Study of IC Engines and a Novel Discussion with a Comprehensive View of Alternative Fuels Used in Petrol and Diesel Engines. *International Journal of Ambient Energy*, *42*(15), 1794–1802.
7. Kholod, N.; Evans, M.; Gusev, E.; Yu, S.; Malyshev, V.; Tretyakova, S.; Barinov, A. (2016) "A Methodology for Calculating Transport Emissions in Cities with Limited Traffic Data": A Case Study of Diesel Particulates and Black Carbon Emissions in Murmansk. *Sci. Total. Environ*, 547, 305–313.