ISSN No:-2456-2165

Analysis of the Exhaust Emissions from Single Cylinder Non-Mobile Spark Ignition Generator Fuelled with Petrol and LPG Alternatively

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Abstract:- The precarious challenge of the economic development in Nigeria is not far from its epileptic power supply. This challenge makes the use of electric power generators for both commercial and domestic purposes inevitable. The most common fuel used for powering these electric generators is gasoline. In the light of the abundant availability of natural gas in Nigeria this work set out to examine the exhaust emission of gasoline and LPG using a Kane Auto 4-1 & 5-1 Series Exhaust Gas Analyser which measures CO, HC, O_2, CO_2, emissions. The test engine was a single cylinder spark ignition Senwei portable generator fitted with a dual carburetor, hence can run on both fuel. The emission was recorded for varying load from 0 - 1200 watts for both fuels. The result shows that LPG emission for CO and HC was higher than for gasoline. The HC emission for LPG at idle running and low loads was very high and Gasoline CO_2 emission was higher than LPG.

Keywords:- *Emission Characterization, LPG, Gasoline, Energy.*

I. INTRODUCTION

The backbone and foundation of modern civilization is availability and affordability of energy. The sustainable development of a nation, its economical and infrastructural progress is predicated on and access to energy. Availability of energy is a vital key towards poverty eradication and economic development of a nation, as it is a measure of the prosperity of a nation as its per capital energy consumption is a measure of its per capital income (1) (2).

Nigeria is endowed with a rich combination of energy resources in such quantities that a prudent, careful and systematic exploitation of such resources will lead to a rapid growth and development of the country making it a force to be reckoned with in world economy (3).

The precarious challenge of the energy sector in Nigeria is not far from the issues of, slow and non-implementation of energy policy, poor energy mix, inadequate and epileptic power supply, lack of drive towards energy security and sustainability, corruption, ineptitude and inadequate private sector participation. In spite of its huge primary energy resources both renewable and non-renewable energy sources, energy situation in Nigeria need serious attention (4).

Some of the other energy resources available in the country includes: tar sands, natural gas and coal, abundant sunlight and significant wind and hydropower.

In1956 oil was discovered at Oloibiri in Niger Delta region. Two years later in 1958 Nigeria joined the ranks of oil producers producing 5,100 barrels per day (bpd) when its first oil field came on stream. Nigeria oil reserve is estimated around 37.2 billion bpd, with over 159 oil fields and 1,481 wells producing an estimated 2.4 million bpd (4).In 2006, Nigeria was ranked the 10th largest crude oil producer in the world with a reserve estimated to be about 36 million barrels, which is about 4.9 billion ton of oil equivalent (toe) (5).

Nigeria natural gas reserve is estimated around187 Trillion Cubic Feet (TCF), ranking the seventh largest in the world. Nigeria natural gas occurs in crude oil reserves as free gas (that is it is associated), it is a high grade gas with 0% sulphur. Lack of necessary infrastructure led to the flaring of 43% of the total natural gas production (4).

Nigeria in 2008 exported about 3 billion cubic feet of gas per day (in the form of LNG), at the same time flaring approximately 2.5 billion cubic feet per day. Only 0.5 billion cubic feet per day was delivered to the domestic power sector. Natural gas resources in Nigeria are grossly under-utilized domestically (6).

- *Gasoline*

Gasoline is a liquid mixture. It primarily consists of two liquids isooctane and heptanes. It is a product of the fractional distillation of crude oil. It is highly flammable and volatile. Additives such as antiknock are added to it so it can be suitable for use in spark ignition engines- automobiles, airplane and other engines (7).

- *LPG*

Liquefied petroleum gas (LPG) is also a petroleum product. It is a colorless gas. The components of LPG basically are propane and butane and natural gas (methane) (8) (9)

An exhaust analysis is an examination of the components of an engine's emission gases, vapors, and particulates. The information from an exhaust analysis can be used for different purposes (11). Exhaust emissions are the non-useable gaseous waste products produced during the combustion process.

There are two factors that determine the exhaust emissions of an engine: the type of fuel and the engine operating parameters which would include: speed, load, engine temperature, air-fuel ratio and spark timing (12).

The combustion product and emission from internal combustion engine includes: nitrogen oxides (NO_x), carbon monoxides (CO), hydrocarbon (HC) and particulates (PM). These exhaust products are sources of serious health problems and environment concern. This concern is a worldwide concern as it accelerates global warming and climatic change. Exhaust gases containing lead affect human health as it reduces human mental ability; raise the blood pressure, cause damage to blood, nerves and other organs in the body (13). There is a growing interest in alternative fuels largely due to the need of reducing or limiting emissions from vehicle and other fuel powered engines such alternatives being investigated include dimethyl ether (DME),natural gas - methane (CNG - compressed natural gas), hydrogen fuel, liquefied petroleum gas (LPG), bio-diesel and so on. LPG which is a colorless gas comprised of various hydrocarbons mainly propane and butane and natural gas (methane), occurring naturally in the earth are of primary interest. The growing interest is largely due to financial and ecological reasons (8).

II. EXPERIMENTAL SET UP

The Kane Auto 4-1 & 5-1 Series Exhaust Gas Analysers used in this work measures CO, HC, O2, CO_2, and Lambda (or AFR) weighs just 1kg and can run for up to 4 hours on its internal re-chargeable battery.

The table of the specification of the analyser is given below

Parameter	Resolution	Accuracy	Range
Carbon Monoxide	0.01%	±5% of reading[*1] ±0.06% volume[*1]	0-10% Over-range 20%
Oxygen 02 (Fuel Cell)	0.01%	±5% of reading [*1] ±0.1% volume[*1]	0-25% Over-range 48%
Hydrocarbon (HC-hexane) (NDIR)	1ppm	±5% of reading[*1] ±12ppm volume[*1]	0-3000ppm Over-range: 10,000ppm
Carbon Dioxide (Infrared)	1ppm	±5% of reading[*1] ±0.5% volume[*1]	0-16% Over-range: 25%
Nitric Oxide[*2] (fuel cell)	1ppm	0-4000ppm ±4% or 25ppm; 4000 - 5000ppm ±5%	0-5000ppm
Oil Temperature	0.1°C/F	±2.0°C±0.3% of reading ±3.6°F±0.3% of reading	0-150°C 32-302°F
RMP	1 rpm	50 rpm	200-6,000 rpm.
Carbon Monoxide Corrected CO	0.01%	Calculated	0-15%
Lambda AFR (Petrol) (LPG)	0.001 00.01		0.8 - 1.2 11.76 - 17.64 12.48 - 18.72

Table 1:- showing the specification of gas analyser

➢ *The Load Bank*

In this experiment, a bank of several light bulbs was used to vary the electric load to be powered by the generator. To increase the engine loading more bulbs will be powered, to decrease the engine load fewer bulbs were powered. This "load board" then consisted of different light bulbs of 100 – 200 watts each, wired in parallel, with every bulb a switch, to allow easy load variation for flexible testing.

Fig 1:- Test engine and load bank

➢ *Test engine*

The test engine is a 220V, 1.0KVA rated electric generator, with a DC output of 12V/8.3A It is single cylinder spark ignition Senwei portable generator fitted with a dual carburetor for LPG and gasoline. The dual carburetor enables the test engine to run on Gasoline and LPG alternate

Fig 2:- Diagram of dual carburetor for LPG and Gasoline (14).

➢ *Test procedure*

The test engine was fitted with a dual carburetor that can run on gasoline and LPG. Thus it was fueled with Gasoline and LPG in turn. The setup load varies from 0 – 1200Watts. After the engine has run for at least ten minutes a series of reading is taken using a Kane Auto 4-1 & 5-1 Series Exhaust Gas Analysers which measures CO, HC, O_2, and CO_2 at regular intervals and the average exhaust emission result recorded.

III. RESULT

Sample	Load (kW)	HC(ppm)	CO(%vol)	CO_2(%vol)
LPG	0.0	4.63	3.0	1441
	0.4	5.76	3.8	1618
	0.8	6.96	4.5	254
	1.2	7.45	4.9	252
GASOLINE	0.0	3.41	7.8	47
	0.4	3.36	7.0	62
	0.8	4.33	7.6	99
	1.2	6.32	7.7	132

Table 2:- Average emission result for LPG and Gasoline

IV. DISCUSSION

➢ *CO Emission*

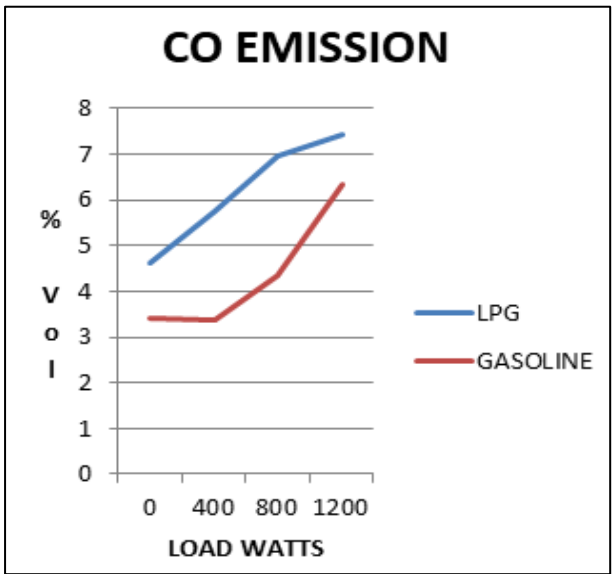

Fig 3:- CO emission comparism for LPG and Gasoline

Carbon monoxide CO is formed as a result of incomplete combustion of fuel. CO emission increases for both LPG and Gasoline but LPG emission is greater than for gasoline. For LPG it increases from 4.63% Vol to 7.45% Vol while gasoline increases from 3.41% Vol to 6.32% Vol.

➢ *CO_2 Emission*

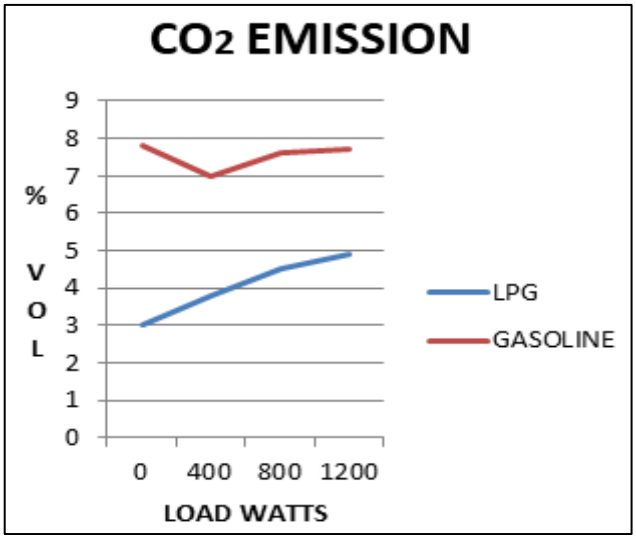

Fig 4:- CO_2 emission comparism for LPG and Gasoline

CO_2 emission for gasoline is higher than for LPG. There are no significant changes in the values for Gasoline while LPG increases from 3.0% Vol to 4.9% Vol. It is worthy to note that gaseous fuels contain more hydrogen and less carbon than Gasoline or Diesel fuel, therefore its higher carbon fractions tends to produce more carbon dioxide CO2 (9).

ISSN No:-2456-2165

➢ *HC emission*

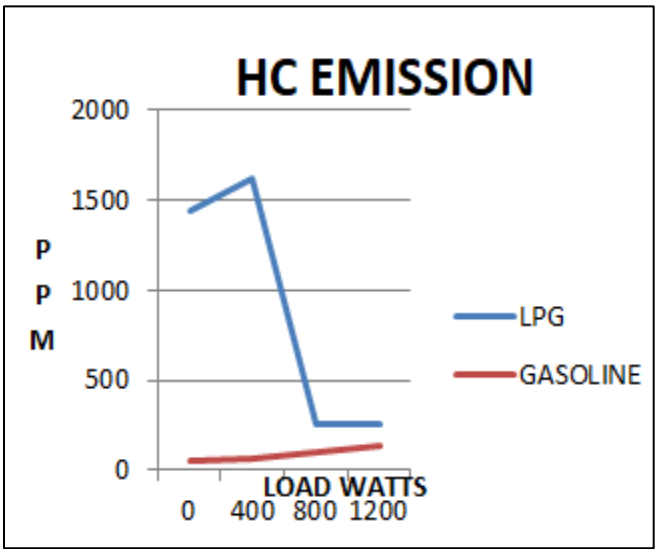

Fig 5:- HC emission comparism for LPG and Gasoline

HC emission is extremely high at idle and low load for LPG. HC emission for gasoline increases with increasing load from 47ppm to132ppm.

V. CONCLUSION

This write up compared the exhaust emission of LPG and Gasoline using a Kane Auto 4-1 & 5-1 Series Exhaust Gas Analyser which measures CO, HC, O_2, CO_2 emission. The test engine was a single cylinder spark ignition Senwei portable generator fitted with a dual carburetor, hence can run on both fuel. The emission was recorded for varying load from 0 - 1200 watts for both fuel fuels. The result shows that LPG emission for CO and HC was higher than for gasoline. The HC emission for LPG at idle running and low loads was very high. Gasoline CO_2 emission was higher than LPG.

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