Journal of Petroleum and Gas Engineering Vol. 1(2), pp. 37-40, June 2010
Available online at http://www.academicjournals.org/JPGE


*Full Length Research Paper*

# Experimental study on the effects of kerosene-doped gasoline on gasoline-powered engine performance characteristics

**O. Obodeh* and N. C. Akhere**

Mechanical Engineering Department, Ambrose Alli University, Ekpoma, Edo State, Nigeria.

Accepted 19 April, 2010

**This investigation was carried out to study the engine-out emissions from a four-stroke, four-cylinder, water-cooled spark ignition (SI) engine with kerosene blended gasoline with different proportions of kerosene ranging from 0 - 50% by volume in step of 10%. Gaseous exhaust emissions were measured with the aid of pocket gas ™-portable gas analyzer. The experimental results showed that the engine-out emissions increase with increase concentration of kerosene in the blend. The analyses gave increase ranging from 21.7 - 53% for carbon monoxide (CO), 23.4 - 57.1% for unburnt hydrocarbon (HC) and 2.4 - 8.2% for particulate matter (PM). The experiment also showed increase in specific fuel consumption (SFC) for all load conditions ranging form 34 - 36%. Measures needed to reduce fuel adulteration were suggested. The measures encompass effective monitoring mechanism and enforcement of heavy penalty on sale of adulterated fuels.**

**Key words:** Kerosene-gasoline blend, gasoline engine, engine-out emissions.

## INTRODUCTION

Where different products of comparable qualities have different prices or consumers have no efficient tools to distinguish similar products of different qualities, unscrupulous operators will always try to exploit the situation for illegal profits. Illegal practices in the retail business is a global phenomenon, and fuel adulteration is one of the major abuses along with under-dispensing products to customers, mislabeling the octane number of gasoline, labeling leaded gasoline as unleaded and forging customs declarations or smuggling fuel to avoid or reduce excise duty payments (NNPC, 2007). These practices lead to losses in several areas, which include damaging engines and worsening air quality (Ale, 2003; Fonseca et al., 2007; Kamil et al., 2008). Evading fuel taxes reduces government revenue. Under-dispensing supplies to consumers lead to consumer losses. Doping gasoline with solvents and other chemicals can leave harmful deposits in engines (Biswas and Ray, 2001).

In Nigeria, the adulteration of gasoline is normally indulged primary due to the significant price differential between products. Adulteration is defined as the introduction of foreign substance into gasoline illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product (NNPC, 2007). The foreign substances are also called adulterants which when introduced alter and degrade the quality of the base transport fuels. Gasoline is a major transport fuel in Nigeria. Adulteration of the fuel at the point of sale and during transportation has become an acute problem in the country (Igbafe and Ogbe, 2005). Transport fuels (gasoline and diesel) are often adulterated with other cheaper products or byproduct or waste hydrocarbon stream for monetary gains. For example, gasoline is widely adulterated with kerosene. With large number of adulterants available in the market, both indigenous and imported, the magnitude of the problem of fuel adulterations has grown into alarming proportions in the past few years.

The poor in Nigeria depend on kerosene for their cooking energy needs. Kerosene is subsidized to address

*Corresponding author. E-mail: engobodeh@yahoo.com.

the energy accessibility issues of the poor especially the cooking energy needs (Igbafe and Ogbe, 2005). Currently, gasoline is sold in major cities for ₦65 per liter while kerosene is sold in Mega-Filling stations at ₦50 per liter. The price differentiate has resulted in illegal diversion of kerosene meant for cooking energy needs of the poor towards adulteration of transport fuels.

Stringent norms are being advocated all over the world to reduce emissions from transport systems (Gupta, 2001; Mohan et al., 2006). However no strategy for emission reduction can be successful without addressing the issue of fuel adulteration (Mohan et al., 2006). The objective of this study is to analyze and identify the different exhaust emissions from the combustion of kerosene-doped gasoline and compare the emissions with that of pure gasoline operation.

## MATERIALS AND METHODS

A four-stroke, four-cylinder, water-cooled, spark-ignition engine of brake power 60 kW at rated speed of 4600 rpm was used. The engine specifications are as shown in Table 1.

Fuels (gasoline and kerosene) were bought from a major oil marketer (Texaco Filling Station, Ekpoma). The chemical compositions of fuels used are presented in Table 2.

For the mixture preparation of gasoline and kerosene, six sets of sample mixture were prepared in 100: 00, 90:10, 80: 20, 70: 30, 60: 40, 50: 50 ratios.

Tests of engine performance on pure gasoline (100: 00) were conducted as a basis for comparison. The engine was run on "no load" condition and its speed adjusted to 4500 rpm by adjusting the fuel control valve. The test engine was run to attain uniform speed and then it was gradually loaded. The experiments were conducted at five load conditions of 0 (no load), 25, 50, 75 and 100% of the rated load. For each load condition, the engine was run for at least 20 min. The experiments were repeated with other samples namely: 90:10, 80:20, 70:30, 60: 40, and 50: 50 ratios.

The speed and load of the engine were controlled independently by the fuel control system and dynamometer. Air flow rate was measured using a laminar flow element and fuel flow rate was measured using a positive displacement meter. DIGICON model DT-240P non-contact tachometer with the range from 5 - 10,000 rpm and resolution of 1 rpm was used to measure the engine speed. Gaseous exhaust emissions were measured with the aid of pocket gas $^{TM}$-portable gas analyzer. During the experiments, the average ambient temperature and atmospheric pressure were recorded as 30°C and 756 mmHg respectively.

## RESULTS AND DISCUSSION

The variation of carbon monoxide (CO) emissions with different proportions of kerosene by volume in the kerosene-gasoline blend at different load conditions is shown in Figure 1.

As the concentration of kerosene in gasoline increases, the value of CO increases, for 10% adulteration it was 21.7% and for 50% mix, the value was 53%. This is due to incomplete combustion of fuel owing to higher density and viscosity with poor volatile property of kerosene when compared to pure gasoline (Usha et al., 2003; Igbafe and Ogbe, 2005).

Figure 2 illustrates the percentage change of hydrocarbon (HC) emissions due to adulteration of gasoline with kerosene.

On adulteration with kerosene, HC increases significantly. On 10% adulteration, the percentage increase was 23.4% while that for 50% adulteration was 57.1%. This is due to increase in quenching effect with poor volatility of kerosene when compared to pure gasoline. Kerosene, being a mixture of low volatility, high molecular weight hydrocarbons ($C_{10}H_{22}$ to $C_{16}H_{34}$) than gasoline ($C_5H_{12}$ to $C_9H_{34}$) is more prone to emit more HC and CO in the exhaust of spark ignition (SI) engine due to less effective combustion (Muralikrisha et al., 2006).

Consequences of incomplete combustion of fuel are increased absorption of heavier HC components in engine oil film which escapes the combustion process. Increased portion of heavier HC components remain in liquid phase and may escapes the combustion process. This contributes to photochemical smog (Perola et al., 2003; Ghose et al., 2004).

The particulate matter (PM) emissions increase with increase in percentage of kerosene in the blend as shown in Figure 3.

On 10% adulteration, the percentage increase was 2.4% while that for 50% adulteration was 8.2%. The in-cylinder liquid fuel (droplets or pool), if ignited by the flame, produces PM via formation, growth and pyrolysis of polycyclic aromatic hydrocarbons (PAHs). PAHs are also adsorbed on PM (Perola et al., 2003). PAH increases with increase in the naphthene content of the fuel (Table 2). In addition, the use of fuels with higher density results in higher emissions of PM and smoke (Heywood, 1988). This is due to the fact that PM emission is dependent of molecular weight and volatility of fuel (Heywood, 1988). The effects of blending gasoline with kerosene are increased density, decreased volatility and reduced octane rating (Fonseca et al., 2007). When gasoline was doped with kerosene in higher concentration, it was difficult to start the engine and there was also possibility of knock (knock is noise generated when auto-ignition of a portion of end gas takes place ahead of propagating flame). Since the octane number of kerosene is lower than that of gasoline, kerosene-adulterated gasoline will cause knocking of the engine (Fonseca et al., 2007). This was noticed when the engine was run with the adulterated fuel in the ratio of 50% kerosene and 50% gasoline. There is also possibility of carbon deposits on the spark plug, piston head and valves (Heywood, 1988).

The variation of specific fuel consumption (SFC) as a function of different proportions of kerosene by volume in the kerosene-gasoline blend at different load conditions is shown in Figure 4.

Increase in SFC for all load conditions ranges from 34 - 36% compared to pure gasoline operation. Increase in fuel consumption rate is attributed to lower heating value of kerosene as compared to pure gasoline (Biswas and Ray, 2001; Kamil et al., 2008). In other words, more fuel

**Table 1.** Test engine specifications.

| Parameter | Value |
|---|---|
| Make and model | 2.0 SLX Nissan Gasoline |
| Year of manufacture | 1988 |
| Type | 4-Stroke, in-line |
| Number of cylinder | 4 |
| Bore | 88 mm |
| Stroke | 82 mm |
| Displacement | 1994 $mm^3$ |
| Compression ratio | 8.2:1 |
| Air induction | Naturally aspirated, water cooled |
| Valves per cylinder | 4 |
| Number of plugs | 4 |
| Maximum power | 60 kW at 4600 rpm |
| Maximum torque | 144 Nm at 3000 rpm |
| Maximum speed | 5000 rpm |

**Table 2.** Chemical composition of fuel used.

| Fuel | Paraffins (%vol.) | Naphthenes (%vol.) | Olefins (%vol.) | Aromatics (%vol.) |
|---|---|---|---|---|
| Gasoline | 42 | 4 | 17 | 35 |
| Kerosene | 55 | 28 | 0 | 16 |

Source: Fonseca et al., 2007.

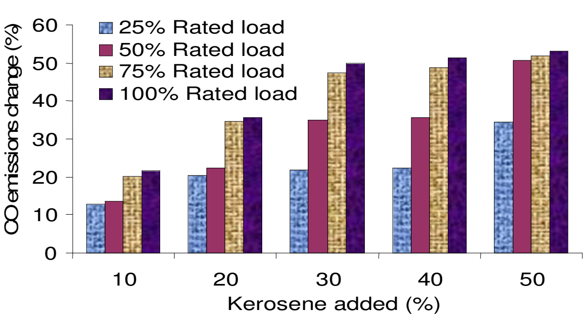


**Figure 1.** Variation of co-emission as a function of kerosene added.

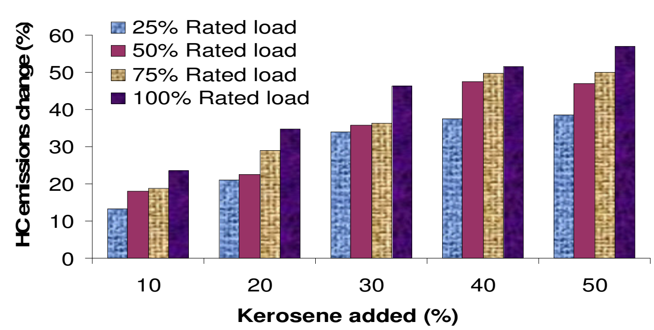


**Figure 2.** Variation of HC as a function of kerosene added.

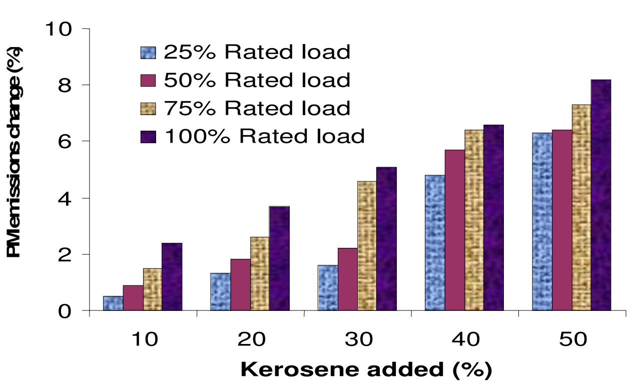


**Figure 3.** Variation of PM emission as a function of Kerosene added.

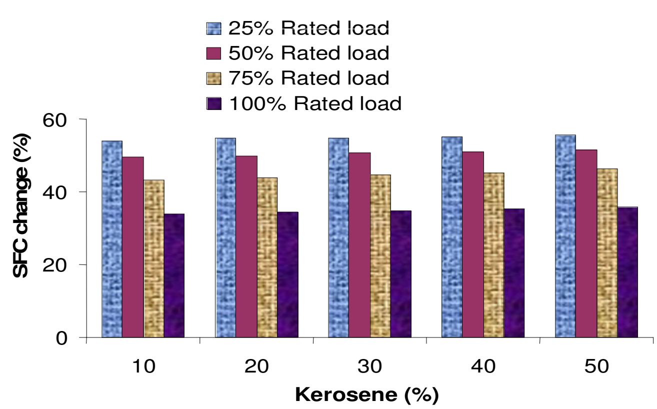


**Figure 4.** Variation of SFC as a function of kerosene added.

is needed in order to produce the same amount of energy. The consistent increase in the SFC with increase amount of kerosene in the fuel blends is due to more fuel supplied to the engine in order to maintain constant brake mean effective pressure.

## Conclusion

An experimental investigation has been carried out to evaluate the effect of kerosene-doped gasoline on the engine-out emissions and performance of gasoline-powered engine. The experimental results showed that the engine-out emissions increase with the increase concentration of kerosene in the blend. The analyses gave increase ranging form 21.7 - 53% for CO, 23.4 - 57.1% for HC and 2.4 - 8.25 for PM. Increase in SFC for all load conditions ranges from 34 - 36% compared to pure gasoline operation. On 50% adulteration, it was a bit difficult to start the engine.

The experiment also showed that blending kerosene with gasoline increased knocking tendency drastically. This is due to the accumulation of the heavier fractions in the cylinders of the engine (Heywood, 1988).

To curb fuel adulteration, oil companies should carryout filter paper test, density checks, blue dyeing of kerosene. Oil companies and government agencies should carryout surprise and regular inspections of retail outlets with mobile laboratories. Heavy penalty on sale of adulterated fuels should be enforced in order to discourage fuel adulteration.

## REFERENCES


Ale BB (2003). Fuel Adulteration and Tailpipe Emissions, J. Inst. Eng. 3(1): 12 - 16.

Biswas D, Ray R (2001). Evaluation of Adulterated Petrol-Fuels, Indian Chem. Eng. J. 43(4): 314 - 317.

Fonseca MM, Yoshida MI, Fortes ICP, Pasa VMD (2007). Thermogravimetric Study of Kerosene-Doped Gasoline, J. Therm. Anal. Calorim. 87(2): 499 - 503.

Ghose MK, Paul R, Benerjee SK (2004). Assessment of the Impact of Vehicle Pollution on Urban Air Quality, J. Environ. Sci. Eng. 46(1): 33 - 40.

Gupta A (2001). Fuel Adulteration- Complexities and Options to Combat, Proceedings of 4th International Petroleum Conference and Exhibition, New Delhi, October 10-12: 162-165.

Heywood JB (1988). Internal Combustion Engine Fundamentals, McGraw-Hill Book Co., New York pp. 915-916.

Igbafe AI, Ogbe MP (2005). Ambient Air Monitoring for Carbon monoxide from Engine Emission in Benin City, Nigeria, Afr. J. Sci. Technol. 1(2): 208 - 212.

Kamil M, Sardar N, Ansari MY (2008). Experimental Study on Adulterated Gasoline and Diesel Fuels, Indian Chem. Eng. J. 89(1): 23 - 28.

Mohan D, Agrawal AK, Singh RS (2006). Standardization for Automotive Exhaust Pollution: Some Issues in Indian Perspective, J. Inst. Eng. 86: 39 - 43.

Muralikrisha MVS, Kishor K, Venkata RD (2006). Studies on Exhaust Emissions of Catalytic Coated Spark Ignition Engine with Adulterated Gasoline, J. Environ. Sci. Eng. 48(2): 97 - 102.

NNPC (2008). Warri Refining and Petrochemical Co. LTD, Technical Report 4: 74 - 76.

Perola VC, Zacarias D, Pires AF, Pool CS, Carvlho RF (2003). Measurements of Polycyclic Aromatic Hydrocarbons in Airborne Particles from the Metropolitan Area of Sao Paulo City, Brazil, Atmospheric Environ. 37(21): 3009 - 3018.

Usha MT, Srinivas T, Ramakrishna KA (2003). Study on Automobile Exhaust Pollution with Regard to Carbon monoxide Emissions, Nat., Environ. Pollut. Technol. 2(4): 473 - 474.