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Performance Evaluation of Spark Ignition Engine at Constant Load Using Ethanol as Doping Agent

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Abstract This project work is significant globally as the world is raising concern on global environmental challenges seen in recent times. Just of recent, the president of Nigeria Dr. Goodluck Jonathan was at UN Convention held at Geneva to join in world to deliberate on sustainable Energy and global warming issues. One critical source of environmental pollution is found to be associated with S.I. Engines running on Leaded Petrol. This Leaded Petrol contains Lead Compound known as Tetra Ethyl Lead (TEL) which gives out a poisonous substance. TEL is known with its ability to resist knock and raise octane rating. This paper examines the effect of replacing poisonous lead use as anti-knock agent with alcohol. The sources of alcohol in Nigeria are numerous and includes Woodchips which is non-edible Lignocelluosic Biomass. Alcohol obtained from these sources was blended with Petrol at different Blend ratio of 5% 10%, 15%, 20%, 30% and 40%. The purpose of blending is to obtain an optimum anti-knock blend ratio resulting to satisfactory engine operations. Alcohol is a renewable energy which is environmentally friendly. The test run of the blends was made on S.I Engine. The Engine Performance was evaluated at full-load condition. The results show that at full load, 20/80 ethanol/petrol blend gave the optimum engine performance.

Keywords: *brake power, BSFC, fuel consumption, thermal efficiency*

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1. Introduction

The materials use in petrol doping around the world are great threat to human life and environment. This anchored our desire to find the suitability of blending Petrol with various feed stocks of alcohol in place of TEL used as anti-knock agent. Edible and non edible feedstock are also being considered for qualitative and reliable Ethanol production. [15,17] In modern automobiles (S.I Engine), the level of petrol suitability is of great concern to performance and environment. S.I. Engine knock is among the most disturbing problems a vehicle can have, which has lead to the use of more poisonous substances to ameliorate the problems arising from Engine knock. [7,8] Wayne Hall stated that in early 1990's, USA experienced a decline in crime which was unprecedented and contradicts the predicted increase in crime rate. The rate of all kinds of crime decline steeply across all demographical groups and in virtually all geographical regions in USA. [6] It was also hypnotized that Lead exposure was criminogenic as it leads to reduce IQ, increase impulsiveness, aggressiveness, and causes problems in Late childhood. [3] EPA in 1975 specified that over a five year period, the average lead content of petrol would be reduced from 2g to 0.5g per gallon. Wright et al, examined delinquent acts that resulted in arrests in the USA where the participant lived. It was found elevated lead level (13.4, ug/Dl on average during childhood and an elevated risk of arrest which shows 54% have been arrested on a frequency of 800times, and 14% for violent offences. Generally, a blend is a mixture of two or more different substances. A young Engineer at General Motors by name Thomas Midgeley Jr. (May 1889-Nov 1944) discovered that when TEL is added to petrol, there is an absence of unpleasant noise known as Engine Knock or Pinging in Engines when they run. (GM Engineers 2014). [5] The typical agents of antiknock are tetraethyl Lead, Methylcycopentadienyl Manganese Tricarbonyl (MMT), Ferrocene, Iron Pentacarbonyl, toluene, isooctance plus the recent antiknocks agent such as alcohols (methanol, Ethanol, Butanol e.t.c) [5,10,12].

Lead exposure and violent crime are correlated in ecological studies and in a small number of epidemiological studies in the USA and New Zealand [6]. The US clear Air Act Amendments of 1990 Mandates the elimination of Lead from all US vehicle fuel by Jan 1, 1996. In fact unleaded petrol can help extend maintenance intervals. [1,2] Today's cars are built with near perfects pollution control equipment specifically designed to run on unleaded petrol. In recent past, Lead on Spark plugs was the main reason to change them so often. It is a clear point that Africa as a continent has no clear terminal date for the ban of Lead in the member states. It is a norm currently in Nigeria to use of TEL as an antiknock

addictive and octane booster. From 2007 to 2008, the share of ethanol in global petrol use increased from 3.7% to 5.4% [10,19]. In 2011 worldwide ethanol fuel production reached 84.6 billion Litres..[4,9] Ethanol fuel is widely use in Brazil and United States which both countries are responsible for 87.1% of the world's ethanol fuel production in 2011 [9,18]. Reference [16] concluded that ethanol percentage up to 20% in petrol had fuel properties suitable for engines running on spark ignition engines.

2. Instrument and Experimental Procedures

2.1. Instrument

Materials used are: Leaded Petrol, Unleaded Petrol and Ethanol Blend, Tachometer, Dynamometer, Test Tube, Measuring Cylinder, and Reagents. The unleaded petrol used was acquired from Port Harcourt Refining Company (PHRC) Nigeria. The ethanol was extracted from woodchips (sawdust) from a sawmill within Owerri Metropolis. Common woods usually found within the sawmill are (Native Name): Irvingia Gabonensis (Ugiri/Ogbono), Treculia Africana (Ukwa), Pentaclethra Macrophylla (Udala), Precarpus Spp (Ora), Chrysophyllum Albidum (Ube). The sawdust undergoes saccharification process (Simultaneous Saccharification and Fermentation) to convert to glucose which ferments further to give out ethanol. These blends: 5/95, 10/90, 15/85, 20/80, 30/70 and 40/60 ethanol/petrol by volume were characterized in line with America Standard for Testing and Material (ASTM) methods.

ENGINE SPECIFICATIONS

Bore	68mm
Stroke	45mm
Compression Ratio	8.5/1
Rated Speed	2500rev/min
Fuel Tank Capacity	3.6 litres
Number of Cylinder	1
Cooling Medium	Air
Engine Capacity	196CC
Rack Diameter	144mm

2.2. Experimental Procedures

The tests were conducted at full-load conditions using different fuel blends.

For each blend and load, Fuel consumption rate, Engine Speed, torque was measured.

2.3. Characterization Result of Leaded Petrol and Blends

Table 1. Characterization Result of Leaded Petrol and Blends

Sample	Density at 29°C Kg/m^3	Octane No.	Flash Point °C	Calorific Value (MJ/Kg)
Leaded Petrol	746.70	93.20	-65	44.30
5/95	747.10	95.10	-54	43.80
10/90	748.20	97.20	-40	41.80
15/85	752.00	98.60	-36	41.20
20/80	761.30	100.40	-20	38.10
.30/70	775.60	102.70	-15	37.70
40/60	780.20	106.30	-13.5	37.40

The table above shows that addition of ethanol in unleaded petrol increases the density of the blends as well as the octane number. These increase of octane number improves the antiknock quality of the fuel. Calorific value decreases due to low energy content of alcohol and shows the energy transferred as heat to the surrounding per unit quantity of fuel when burn at constant pressure and Table 1 shows a gradual decrease of calorific value as ethanol percentage increases.

3. Results

3.1. Effect of Fuel Blends on Brake Power

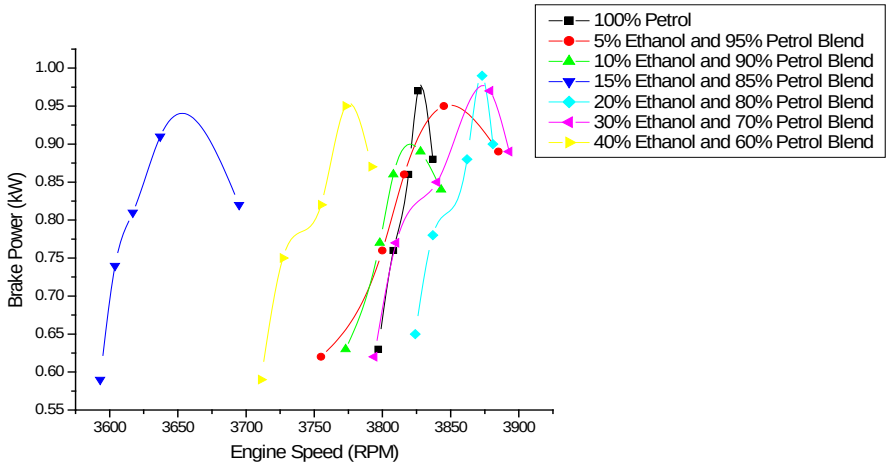

Figure 1. Graphs of Brake Power against Engine Speed

Figure 1 shows the graphs of brake power developed by each blend at full load condition. The figure shows that the blends gave a similar trend. The peak value of brake power of each blend occurs at different engine speeds indicating the variation of the physical-chemical characteristics of the blends. The Engine speed for all blends ranged from 3593 rev/min to 3924 rev /min at full load condition. The brake power is the useful power developed by the engine. The engine developed maximum brake power of 0.99 kW at engine speed of 3873 rev/min when running on 20/80 ethanol/petrol blend. It further shows that the brake power decreases with decreasing

engine speed and increasing fuel flow rate to maintain the load imposed on the engine.

3.2. Effect of Fuel Blends on B S F C

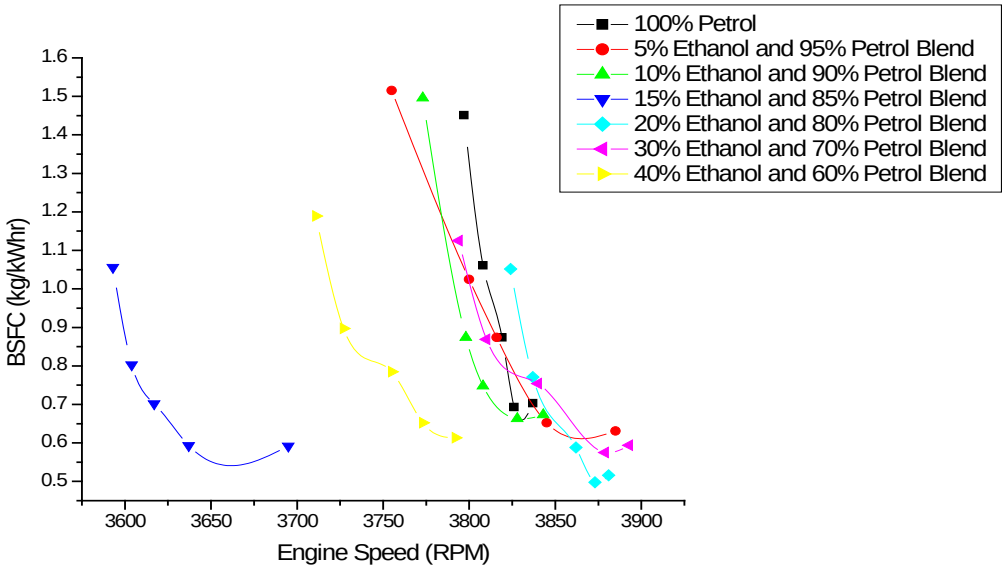

Figure 2. Graph of BSFC for Blends against Engine Speed

Figure 2 illustrates the trends of BSFC for each blend at full-load conditions. The graphs show that increase in Engine speed produces a decrease in BSFC for the blends to certain points before increasing with further increase in engine speed. This is perhaps due to the drop in volumetric efficiency. BSFC indicate the fuel economy with relation to power developed. From the graphs above, 20/80 blend gave the best BSFC of 0.498 kg/kWh.

3.3. Effect of Fuel Blends on Fuel Consumption

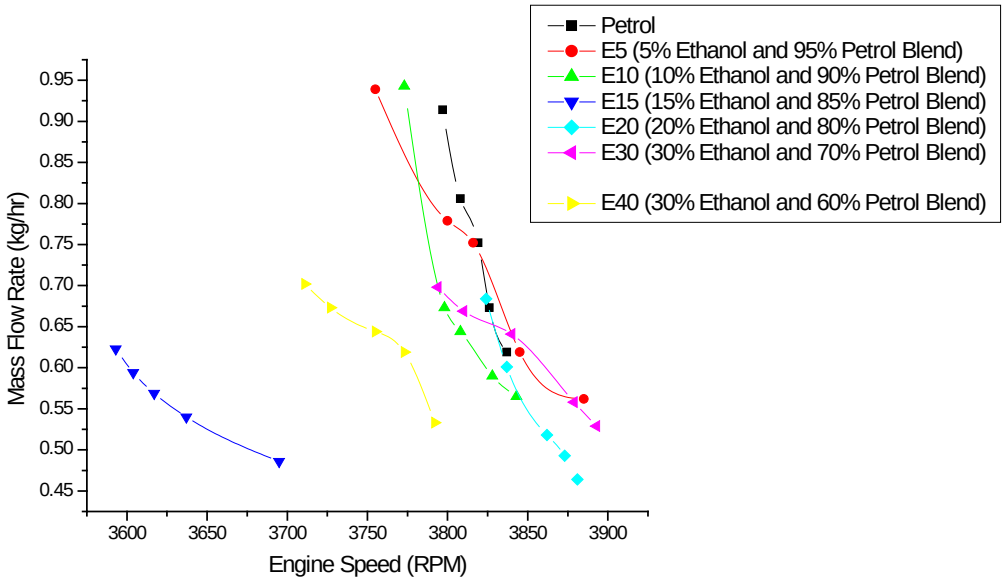

Figure 3. Graphs of Fuel Consumption against Engine Speed

The fuel consumption when running on each blend is superimposed as shown in Figure 3. It is directly dependent on density and calorific value. It was observed from Table 1 that as Ethanol percentage in the blends increases, the denser the blend becomes. Figure 3 shows the fuel consumption of each blend with 20/80 giving the lowest fuel consumption, indicating the optimum blend ratio. The graphs shows that 20/80 blend gave the optimum performance.

3.4. Effect of Fuel Blends on Brake Thermal Efficiency

Figure 4 shows the brake thermal efficiency of the blends at full-load condition. The maximum brake thermal efficiency of 18.96% was obtained when running on 20/80 ethanol/petrol by volume. Since brake thermal efficiency is the ratio of brake power to fuel power, this implies that about 18.96% of the chemical energy of this blend developed power output of 0.99 kW. Figure 4 shows that brake thermal efficiency peaks at a certain engine speed and decreases with further increase in engine speed. It was also noted that the power output took similar trend due to decrease in volumetric efficiency.

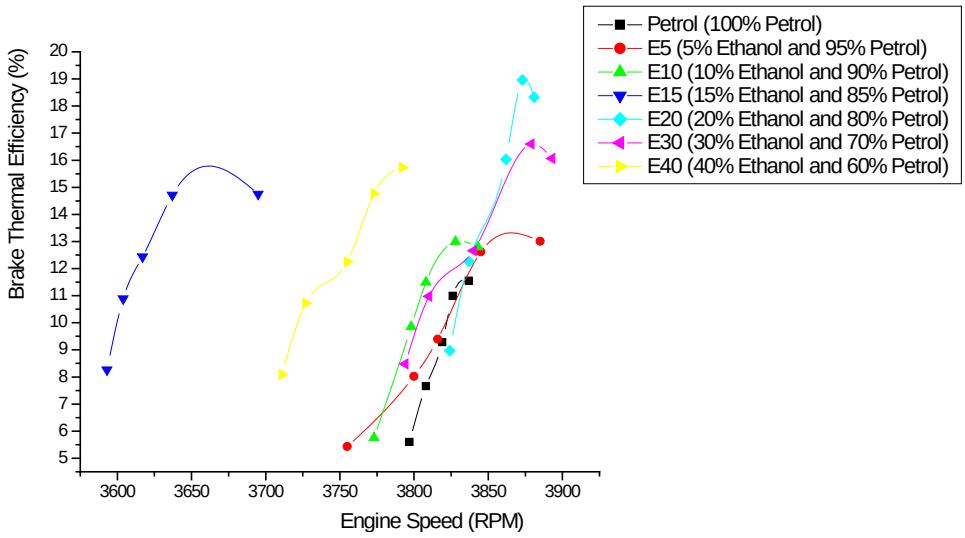

Figure 4. Graphs of Brake Thermal Efficiency against Engine Speed

4. Conclusion

The results obtained when running on Petrol doped with ethanol indicated that maximum power output, low BSFC and low fuel consumption was obtained with 20/80 ethanol/petrol blend. It shows that 20/80 Ethanol/ Petrol blend by volume can offer good alternative antiknock fuel devoid of TEL as antiknock agent.

It raises confidence that with ethanol in fuel used as antiknock agent, modern spark ignition engines will deliver optimum service with little threat to man and environment. The test results showed that for optimum engine performance, the fuel blend of 20/80 (ethanol/petrol by volume) is therefore recommended.

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