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The Performance Characteristics of Petrol-Snot Apple (*Azanzagarckeana*) Bioethanol Blends on Spark Lgnition Engine

[1] Christopher I., [2]Sintali I. S., [3]Abioye A. M. and [4]Alhassan A. M
[1&4]Department of Mechanical Engineering Technology, Federal Polytechnic Bauchi, Nigeria
[2&3]Department of Mechanical/Production Engineering, AbubakarTafawaBalewa University, Bauchi, Nigeria
Emails: cinnocent@fptb.edu.ng, ssibrahim@atbu.edu.ng, amadekunle@atbu.edu.ng, amalhassan@fptb.edu.ng

ABSTRACT

Rapid industrialization and growing population increases demand for energy. Depletion and rise in price of petroleum as well as environmental pollution necessitates the need for alternative source of fuel, hence the need for bioethanol production.In this study, bio-ethanol derived from *Azanzagrakeana* was produced by fermentation method. The physico-chemical and fuel properties of petrol and the bio-ethanol were determined using standard laboratory methods. The blended fuel samples were; PE2, PE4, PE6, PE8, PE10, PE12 and PE14 respectively. The engine performance analysis was conducted to investigate the effect of bio-ethanol as petrol fuel extender, with a TD110-115 single cylinder, four stroke and air-cooled, spark ignition engine test rig, under different loading conditions. The result shows that thespecific fuel consumption was better with petrol than the tested blended fuel samples. In terms of the engine torque, brake power, air-fuel ratio, brake thermal efficiency, PE2, PE4, PE6 and PE8 blended fuel samples have higher performance behaviour up to 1.32% than petrol fuel sample under different loading conditions. While, PE10, PE12, and PE14 fuel samples exhibited a comparatively lower torque, brake power, air-fuel ratio, brake thermal efficiency, and lower specific energy consumption respectively. For reasons of its satisfactory engine performance behaviour, petrol fuel conservation advantages, the candidacy of *Azanzagarckeana* bio-ethanol and gasoline blends, offer a promise of a prospective fuel source for spark ignition engines.

KEYWORDS: Performance, Snot Apple, Bioethanol, Petrol, Engine

I. INTRODUCTION

Energy is crucial for the sustainability of modern societies and its uses are inevitable for human survival. Energy is an essential ingredient for socio economic development and hence, is a true indicator for economic growth. However, the world relies heavily on fossil fuels to meet its energy requirements of which in the near future it will be exhausted. The world total consumption of energy in 2018 from fossil fuel (oil, gas and coal) sources is 84.7%; whereas from all other sources (such as nuclear, hydropower, solar, wind, others) is 15.3% [1]. At this point, energy systems employed for power generation are no doubt overburdened and will be unable to survive with the future energy requirement. The huge quantity of energy being consumed across the world is having an adverse impact on the natural environment.

However, fossil fuels as the main source of energy are taking their toll on the environment. It is recorded that those technologies for fossil fuel extraction, transportation, processing and their combustion have harmful impacts; and storage of petroleum fuel, spills and gas leakages causes water pollution [2].

It is undoubtedly that fossil fuels are currently the most economically available source of power for both commercial and personal uses. Though being thought to be inexhaustible, fossil fuels have been used extensively since the Industrial revolution. However, many believed that the world's reliance on fossil fuels for transport is unsustainable. Some experts also believed that the world has already reached its peak for oil extraction and production, and it is only a matter of time before natural gas and coal follow suit. In addition, fossil fuels are the main reason for global warming, a process that practically all climate scientists said we have to deal with not soon, not tomorrow, but now.

Hence, one of the most promising alternative sources of energy is the bioethanol. Bio-energy represents the utilization of biomass as a source for the production of sustainable fuels and chemicals [3]. Ethanol has long been considered as a suitable alternative to fossil fuels either as a sole fuel in cars with dedicated engines or as an additive in fuel blends with no engine modification requirement when mixed up to 30%. Today, bioethanol is the most leading biofuel and its global production showed an upward trend over the last 25 years with a sharp increase from year 2000 [4].

From existing literature, there are lots of other alternative fuels presently in use, these includes: methanol, methane, natural gas, propane, hydrogen, etc. Nevertheless, the remarkable fuel characteristics of ethanol distinguish it as a better candidate for automobiles. It has high latent heat of vaporization, high octane number and rating, and emission of toxic compounds on its combustion is low [5]. Thus, when ethanol and gasoline are respectively burned in correct stoichiometric ratios, they have about equal volumetric efficiency. When gasoline is burned, it produces water, carbon dioxide, carbon monoxide and other impurities such as; oxides of sulphur and nitrogen, and heavy metal. On the other hand, pure ethanol is burned to produce carbon dioxide, water and a much lower amount of carbon monoxide. Hence, ethanol will be a better replacement for gasoline [6].

The use of ethanol blended with gasoline was a subject of research in the 1980s, and it has shown that ethanol-gasoline blends were technically acceptable for existing gasoline engines. The relatively high cost of ethanol production at that time meant that the fuel could only be considered in case of fuel shortages. Consequently, there has been renewed interest in the ethanol-gasoline blends with a particular emphasis on emission reductions. An additional factor that makes ethanol attractive as a fuel extender or substitute is that it is a renewable resource [7].

II. MATERIALS AND METHODS

2.1 Material/Equipment

The material and equipment used for this work are as follows:

2.1.1 Snot apple (*Azanzagarckeana*)

The Snot applefruits were obtained from Tula in Kaltungo LGA of Gombe state. The material was collected and packaged before it was transported down to the chemistry laboratory at AbubakarTatari Polytechnic (ATAP), Bauchi State where the ethanol extraction, production and characterization process were carried out.

PlateI: SnotApple

2.1.2 Engine test bed

The tests were carried out at the Automobile Laboratory of the Department of Mechanical Engineering, Federal Polytechnic, Bauchi-Nigeria, on a horizontal single cylinder, 4-stroke air-cooled, and 5.6KW engine. The engine model is TecQuipment TD110-115. The engine test bed used to carry out the engine performance tests is shown in plate II and engine technical specifications are given in Table1. The engine was coupled to a manometer and eddy current dynamometer with rated power of 2.43kW at 1500 rpm. The engine was operated at a constant speed of 1500 rpm with variable loads of 500g, 1000g, 1500g, 2000g, 2500g and 3000g. The same test procedure was employed for each set of the blends.

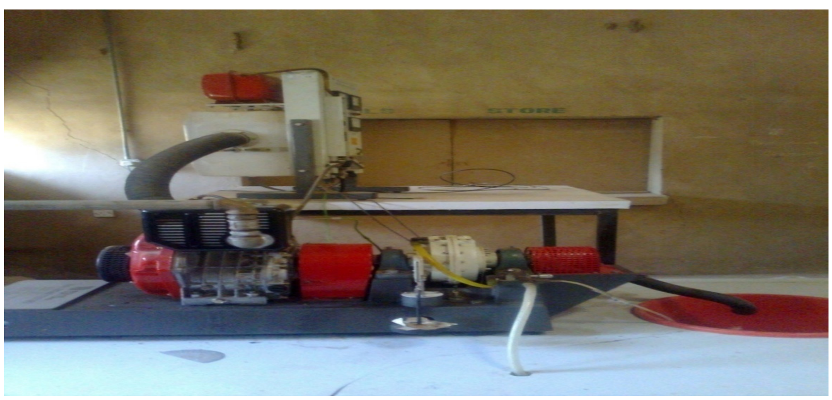


Plate II:Engine Test Bed

Table 1: Specifications of engine test rig

Type	Single cylinder, four stroke, air-cooled
Bore * Stroke	65 mm x 70 mm
Brake power	2.43 KW
Rated speed	1500 rpm
Starting method	Manuel cranking
Compression ratio	20.5:1
Net weight	45 kg
Manufacturer	TQ Educational Training Ltd
Model	TD110-115

Source: TQ (2000).

2.2 Methods

2.2.1 Production of ethanol from snot apple *(Azanzagarckeana)* fruit

The ethanol production processes include; plant collection, chipping of material, mashing of sample into fibre like form, fermentation, filtration, distillation and characterisation. These processes are discussed as follows:

$$C_6H_{12}O_6 + \text{enzymes} \rightarrow 2CH_3CH_2OH + 2\ CO_2 \qquad \ldots (1)$$

The sugars (sucrose, glucose, and fructose) are transformed into ethanol by enzymes contained in an ethanologenic microorganism (yeast *Saccharomyces cerevisiae*).

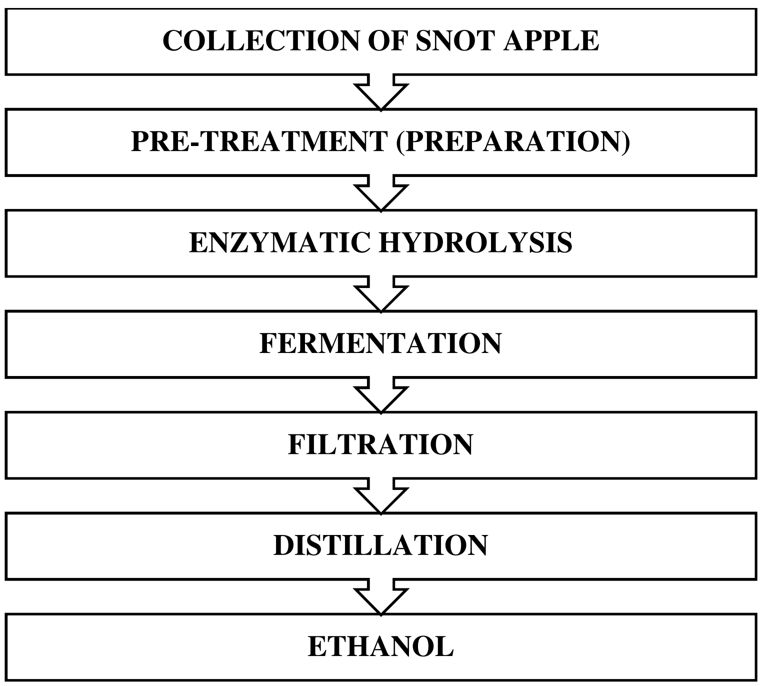


Figure 1:Flow process for ethanol production

2.2.2 Engine Performance Test

The detail of the engine used is given in Table 1. A hydraulic dynamometer was coupled to the engine for torque measurement. Experiments were conducted with gasoline-*Azanzagarckeana* ethanol blends having 2%, 4%, 6%, 8%, 10%,12% and 14%*Azanzagarckeana*ethanol on volume basis at different load levels. The times taken by the engine to consume 8ml of the blended fuels were recorded. The torque, exhaust temperature, speed and barometric pressure for all fuel samples were recorded. Tests on engine performance on petrol were also conducted as a basis for comparison. The percentage of blend and load, were varied and engine performance measurements such as brake specific fuel consumption, air flow rate, brake power, volumetric efficiency, brake thermal efficiency, percentage heat loss and air/fuel ratio were calculated [9].

III. RESULTS AND DISCUSSION

3.1 Engine Performance Analysis

The engine performance of each of the sample was analysed using the graphs.Each of the samples was tested on a Spark Ignition Engine (SIE) model TD110-115 engine test rig and the values of torque, speed, exhaust temperature, time taken to consume eight milliliters (8ml) of fuel and the air flow manometer readings were taken and tabulated

3.1.1 Effect of load on torque

The relationship between the load and the torque for various fuels is shown in figure 2. It was observed that as the load increases, the torque also increases. This was due to increase in fuel consumption with increase in load. When the torque produced at different load for the petrol and various sample mixtures, it was found that the engine load increased to the maximum load of 3000 g for the entire fuel samples tested due to higher viscosity and lower heating value of bio-ethanol [10].
The increase in torque is due to the higher octane number of bio-ethanol, the higher calorific value of petrol and that of the blended mixtures, as well as the enhanced combustion behaviour of the bioethanol blends. In the case of dual fuel mixtures with higher proportions of bio-ethanol, the torque produced is less due to low energy released. Furthermore, the increase in torque and brake power with increase in load could be explained in terms of increase in fuel consumption due to increase of engine load [10].
According to [11], the octane number of the fuel samples could be raised with the addition of ethanol to the petrol fuel, and consequently improves the antiknock behaviour that allows for a more advanced timing, higher combustion pressure and subsequently higher engine output torque.

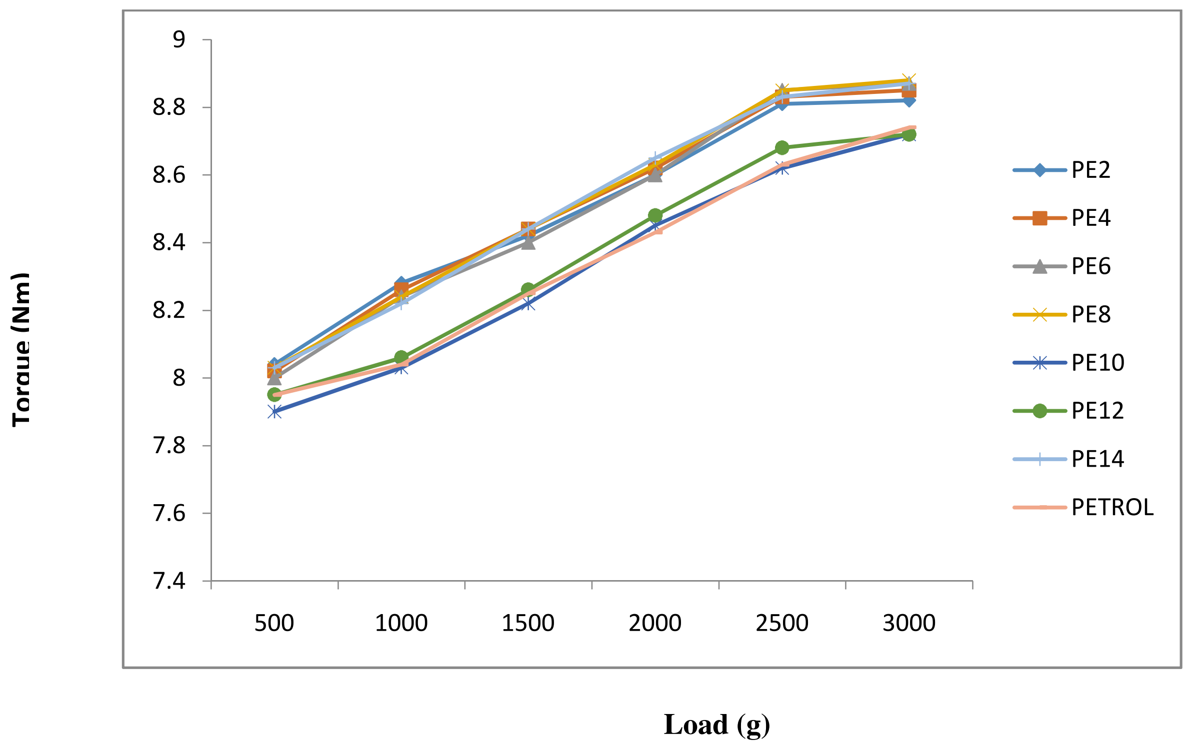


Figure 2: Variation of Torque for Petrol and Petrol-Ethanol Blends with Increase in Load

3.1.2 Brake power

The influence of load on brake power for different fuel is presented in figure 3. It was observed that as the load increases, brake power increase to the maximum at 3000g load. When the brake power produced by the engine at different loads for different mixtures of dual fuel was compared, it was found that the brake power of PE2, PE4, PE6, PE8 and PE14 fuel samples are higher than that of petrol. However, the higher brake power generated by ethanol-petrol fuel blends could be attributed to their improved combustion characteristics has it combines with conventional petrol fuel to burn. The brake power of PE10 fuel sample is almost the same as that of the petrol, while that of PE12 is greater than that of petrol. Since brake power depends on torque, then at higher proportion of bio-ethanol, the torque produce is likely to be lower due to reaction in energy released caused by increased lubricant of bio-ethanol in the blend (Aydin and Bayindir 2010).

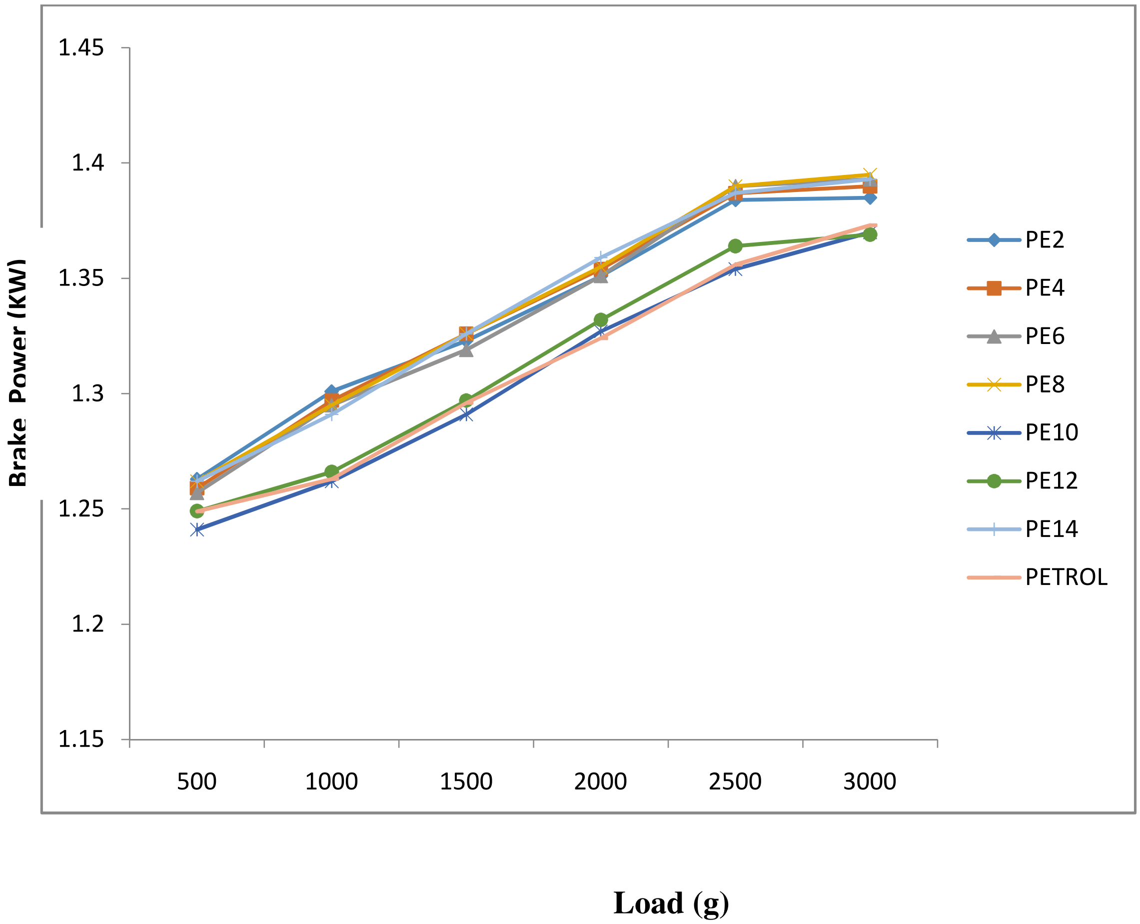


Figure 3: Variation of Brake Power for Petrol and Petrol – Ethanol Blends with Increase in Load

3.1.3 Brake specific fuel consumption

Brake specific fuel consumption (BSFC) is the amount of fuel required to develop unit brake power, and for a given fuel, it is inversely proportional to brake thermal efficiency. The BSFC is a measure of the efficiency of the engine using the fuel supplied to produce work. It is desirable to obtain a lower value of BSFC meaning that the engine used less fuel to produce the same amount of work. BSFC is one of the most important parameters required for comparing and testing various fuels, because it provides a clue on the fuel economy characteristics of the samples under investigation [5].

Figure 4 shows the variation of Brake Specific Fuel Consumption of petrol and various blend samples at different loads. It was observed that as the load increases, Brake Specific Fuel Consumption decreases to the minimum at 3000g loads for the entire fuel sample tested. This improvement in BSFC could be ascribed to better combustion behaviours of the fuel, which could in turn be attributed to the presence of more oxygen molecules in the blend [5].
The specific fuel consumption was found to be lower for all the blended fuel samples than petrol. The high BSFC values of bio-ethanol blended fuel samples could be explained in terms of the combined effect of the lower heating value and the relatively higher fuel flow rate occasioned by the higher density of the blends. As the BSFC was calculated on weight basis, obviously higher densities resulted in higher values for BSFC [5]

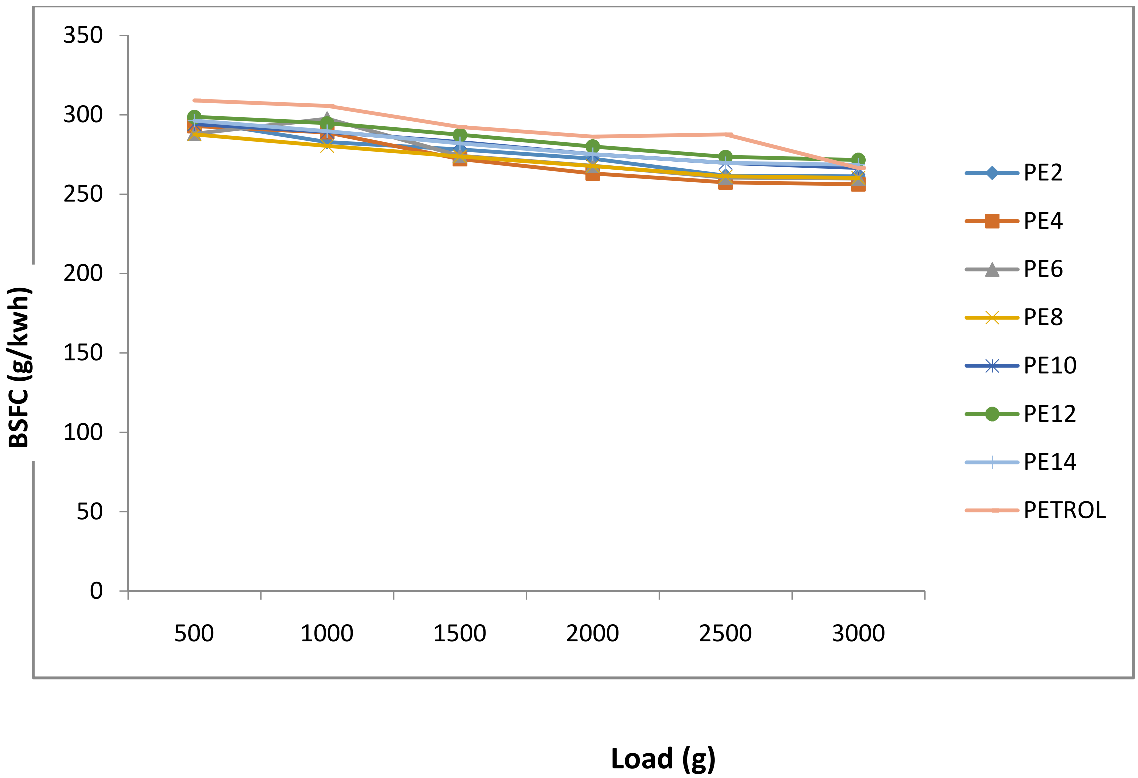


Figure 4: Variation of Specific Fuel Consumption for Petrol and Petrol-Ethanol Blends with Increase in Load

3.1.3 Brake thermal efficiency

Brake thermal efficiency is the ratio between the power output and the energy introduced through fuel injection, the latter being the product of the injected fuel mass flow rate and the lower heating value. Thus, the inverse of brake thermal efficiency is often referred to as brake-specific energy consumption. Brake thermal efficiency (BTE) gives an idea of the output generated by the engine with respect to heat supplied in the form of fuel[10]. The variation of brake thermal efficiency with load is shown in figure 5. For all fuel samples, the brake thermal efficiency increases with increase in load. This can be attributed to the increase in brake power with increase in load. The initial increase in BTE may also be attributed to the near complete combustion of the fuel. At high load conditions a change of state from molecule oxygen to atomic oxygen perhaps lead to a decrease in BTE [10].
The brake thermal efficiency of all the blended samples are higher than that of petrol. It was observed that as the proportion of bio-ethanol in the blends increases the thermal efficiency decreases. The decrease in

brake thermal efficiency with increase in poor atomisation due to higher viscosity could bring about more fuel consumption and combustioninefficiency [10].

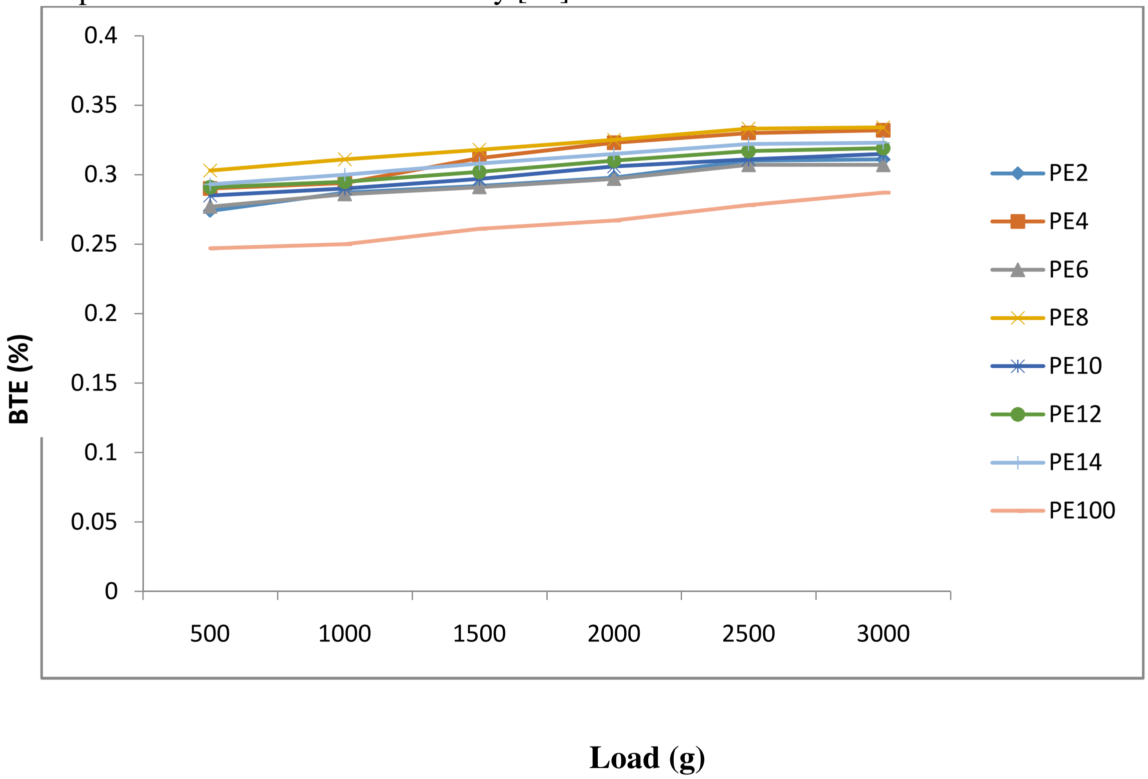
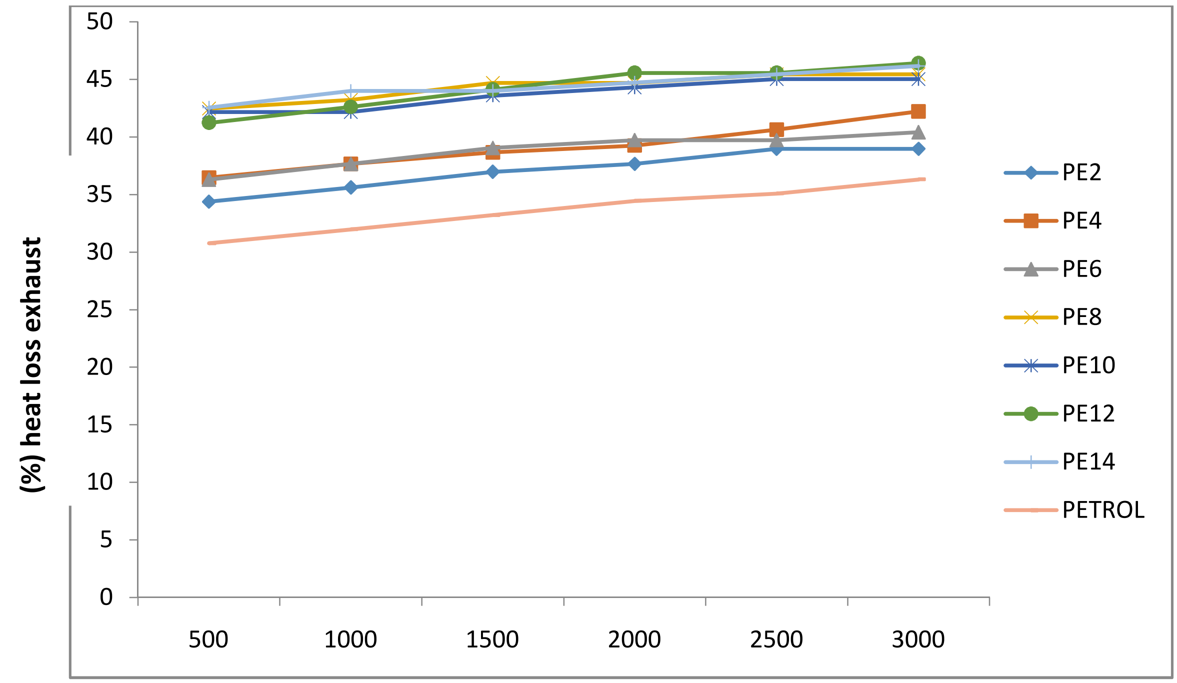


Figure 5: Variation of BTE for Petrol and Petrol-Ethanol Blends with Increase in Load

3.1.5 Percentage heat loss

For Figure 6, all petrol-bioethanol blends show evidence of higher heat losses in engines than petrol fuel. The higher heat loss recorded could be explained in terms of lower calorific (heating) value, increase in fuel density, the difference between the exhaust and ambient temperatures and the size of the engine. However, for heat unaccounted for by losses is partly a function of the engine size, because for smaller engines, considerable conductive and radiative heat losses are usually caused by inefficient combustion [12]. High exhaust gas temperature and reduction in thermal efficiency with increase in blend is an evidence of increase in heat loss [12].



Load (g)

Figure 6: Variation of Percentage Heat Loss for Petrol and Petrol-Ethanol Blends with Increase in Load

IV CONCLUSION

Petrol – *Azanzagarckeana*ethanol blended fuel samples performedsatisfactorily on spark ignition engine without the need for any modification. In terms of torque, Brake power and Brake thermal efficiency, it was observed that PE2, PE4, PE6 and PE8 blended fuel samples have higher performance behaviour up to 1.32% than petrol under different loading conditions. Also, there was increase in fuel economy for the blended samples at different loading conditions.

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