International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 245-252 www.ijaem.net ISSN: 2395-5252

Effect of using N-Butanol-Gasoline blends in Spark Ignition Engine running at constant speed

Abdulrahman A. [1] Nuhu Mohammed [2] Abubakar Usman Babuje [3]
[1]*Senior Research Officer, National Centre for Petroleum Research and Development Bauchi, Nigeria.*
[2, 3] *Lecturer II, Abubakar Tafawa Balewa University, Bauchi, Nigeria.*

Date of Submission: 28-07-2020 Date of Acceptance: 12-08-2020

ABSTRACT:
Spark ignition engine uses derived fuel from petroleum products, depleting of this source as drawn the attention of researchers to find alternative renewable energy sources which could be as additive to petroleum-based fuels. Butanol, when compared to methanol and ethanol, has heating value and octane rating close to that of gasoline. In this study, n-butanol was considered as an additive with gasoline. The engine performance was steered on a TD110-115 single cylinder, four-stroke air-cooled spark ignition engine test rig, at different loading conditions. The blends used for the analysis were 4%, 8%, 12%, 16% and 20%. The blends showed slight reduction in the torque, brake power and exhaust temperature, except for GB4 and GB8 blends. These two blends showed similar torque and brake power performance to those of gasoline at 500 g and 1000 g loading conditions. It was also observed that all the blends exhibited high fuel consumption and lower air–fuel ratio. All blends ran smoothly on spark-ignition engine.

KEYWORDS: N-butanol, Torque, brake power, Exhaust gas temperature, Performance.

I. INTRODUCTION

Biofuel is a kind of fuel that derived energy from biological carbon fixation. These fuels could be solid, gaseous and liquid fuels produced from biomass resources. Liquid biofuels are easier to handle and tend to be cleaner to burn which makes them available in large energy market (for example road and air transportation) compared to the original biomass [1]. Biofuels are the important source of clean energy generation, amongst these categories are few biofuels such as butanol, ethanol and methanol that matches the combustion features of gasoline fuel at relatively low cost, and can be easily adopted for use in existing engine technologies with little or no modification. Butanol, can also be produced from biomass such as corncob, grain, potatoes, sugar beet, grass, plant and tree leaves and also from agriculture waste.

Butanol or n-butyl alcohol or n-butanol is a primary alcohol surround with four carbon structure and the chemical formula C_4H_9OH that have four structural isomers. The isomer of greater commercial interest is n-butanol. Butanol can be produced via chemical synthesis (petro-butanol) and by fermentation (bio-butanol). Butanol in IC engines has been examined by many investigators as a blend with petroleum-based fuels.

[2]. Investigated the performance of an SI engine with different butanol-gasoline blend ratios by simulation. The simulation study was accomplished on a partly loaded engine that was ran on two speeds, 3000 and 4000 rpm. The results showed decrease in the performance of the SI engine.

[3]. Investigated the performance and emission characteristics of single cylinder, 4-stroke SI engine at speed range of 2600 - 3400 rpm (with an increment of 100 rpm). The study was conducted using dual fuel n-butanol and methanol blended with gasoline (1.5%, 3.5% and 5% by volume). The experiment results showed that at low ratio of the blends, reduction was observed for engine volumetric efficiency, brake power, engine torque and exhaust gas temperature. And also, reduction for in-cylinder pressure and CO_2 emission was observed. Increase in emissions of UHC and CO were recorded compared to n-butanol-gasoline blend and gasoline. At higher ratio of the blends showed improved in engine performance and exhaust emission compared to n-butanol-gasoline blend and gasoline.

[4]. Investigated the butanol isomer combustion in multi cylinder, four stroke Homogeneous Charge Compression Ignition (HCCI) engines. In this work, n-butanol and iso-butanol were used as tested fuel samples and then compared with ethanol and gasoline. The results showed that n-butanol and iso-butanol show combustion stability during single stage ignition behaviour. Under all conditions, n-butanol shows more stability and high heat release rate at the beginning of combustion similar to

gasoline. Iso-butanol and other tested fuels showed high knock resistance than n-butanol. N-butanol and iso-butanol showed similar exhaust emission range with other tested fuels.

[5]. Experimentally investigated the effects of using butanol–gasoline-blended fuels on performance, fuel consumption, and emission characteristics of a four-cylinder spark-ignition engine. The butanol-blending fraction used was varied from 10 to 50% by volume. The work was conducted at 2250 and 4250 rpm engine speeds with throttle positions set at 30% and 70%. The results showed that, the flame propagation of combustion process at high throttle position, using the butanol–gasoline blends decrease with increase in the blending fraction and this becomes clearer with the increase of engine speed. At low open throttle position, the engine brake, torque and power were improved, as the blending fraction is less than 30%. A substantial reduction was observed in specific fuel consumption, as the blending fraction is less than 30% for all the tested fuels. The emissions of CO, HC, and CO_2 while using butanol–gasoline blends were reduced than those of pure gasoline. However, higher emission of NOx was recorded for butanol–gasoline blends than that of the pure gasoline.

[6]. This research focuses on the incorporation of various additives in gasoline to reduce pollutants emission and to enhance fuel economy. Gasoline was blended with ethanol and butanol at various ratios to investigate their influence on the engine performance under different operating conditions. The blending ratios of ethanol and butanol to gasoline were 2, 5, 10, 15 and 20%. The fuel consumption of the engine and pollutants emission were measured for all blends at different engine speeds under low loading. The experimental results showed a clear reduction in pollutants emitted from the engine 13.7% for carbon monoxide and 25.2% for hydrocarbons as well as fuel consumption by 8.22%. However, the engine power was negatively impacted and could reach up to 11.1% for the fuel blends.

[7]. Investigated the potential of butanol and algae oil as alternate fuels for SI Engines using blends of gasoline-butanol and gasoline-algae oil. The studies have been carried out on the effect on IC engines under different volume basis of butanol-gasoline blends. The effect of Butanol and Algae addition on combustion of SI engine by considering parameters such as variable compression ratio, algae and butanol blend ratio and loading conditions have been studied. As butanol content in fuel is increased, the efficient combustion process will take place. Further, as the load is increased, the heat release becomes higher in case of pure gasoline, pure diesel and their respective blends with butanol. Also, the different performance parameters like power, emissions, and economy of fuel have been studied. The studies reveal that the power, torque, brake specific energy consumption, Hydrocarbons, Carbon mono-oxides and NO emissions gets improved with butanol addition, whereas NOx and CO_2 emissions are higher than gasoline and diesel. Algae fuel has shown enhancement in the brake specific fuel consumption, NOx, CO emissions and reduced in brake thermal efficiency.

From the above literatures, researches concerning n-butanol–gasoline blends in SI engines, the relationship between the loading conditions, constant speed, and butanol blending ratio, which affect the performance and fuel consumption, of the engine, has not been completely investigated at the same time. Therefore, this present work, showed experimental results conducted with different different loading (500 g to 3000 g) at constant engine speed of 1500 rpm and as well as butanol blending ratios range of 4-20 vol. %. The engine performance in terms of torque, brake power, air to fuel ratio, exhaust gas temperature and brake-specific fuel consumption has been examined and compared for both butanol–gasoline blends and pure gasoline.

II. ENGINE TEST RIG AND SPECIFICATIONS

The engine test rig consists of the engine (TD110), Instrumentation unit (TD114) and Hydraulic Dynamometer (TD115) as shown in Fig. 2.1.

The engine performance was conducted on a single cylinder, four strokes and air-cooled spark ignition engine with the engine specifications shown in Table 2.1.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 245-252 www.ijaem.net ISSN: 2395-5252

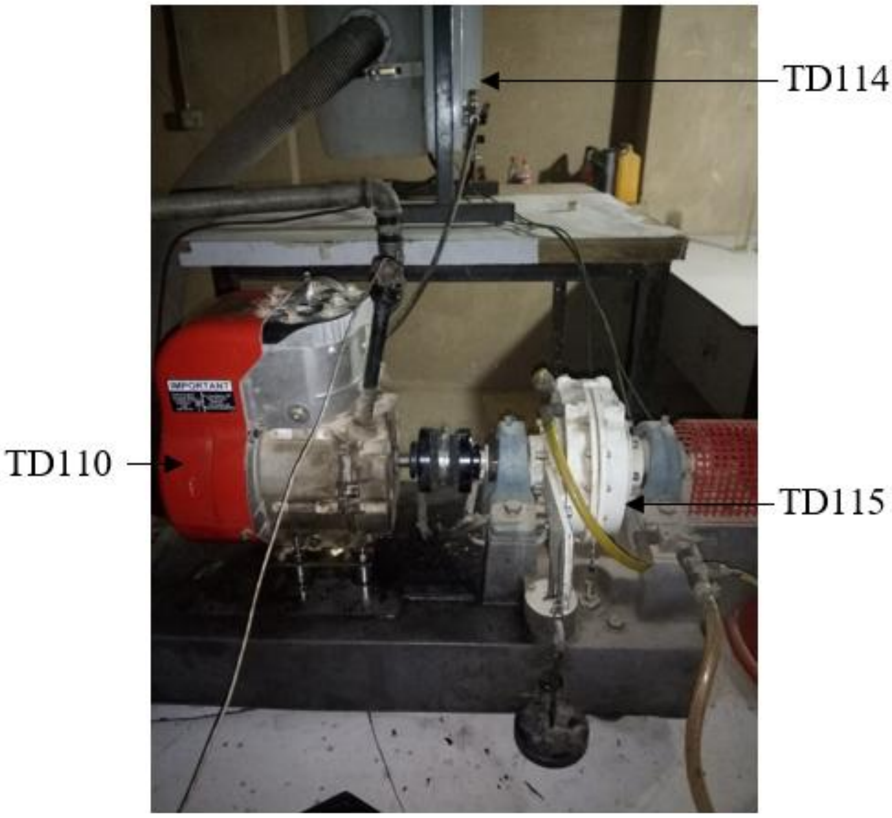


Fig. 2.1: Engine test rig

Table 2.1: Specifications of test rig [8].

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

III. EXPERIMENTATION

3.1 General

Thermometer, barometer and stop watch were used to measure ambient temperature and temperature of water flowing out, barometric pressure and time taken to consume 8 ml of fuel respectively. The Instrumentation Unit consists of the fuel system and the air box/viscous flow meter used to measure the consumption of air.

Engine was started, the throttle or rack was kept open and slowly adjusted the needle valve to increase the flow of water through the dynamometer until the needle valve was fully open. The engine speed was observed till it reached the speed of 1500 rpm which was constant throughout the experiment. When the engine was settled down to the desired

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 245-252 www.ijaem.net ISSN: 2395-5252

steady output, then the fuel tap beneath the pipette was opened, so that engine took fuel from the pipette to measure the time of 8ml fuel consumption. From the instrumentation unit, the readings of speed, torque and exhaust gas temperature were recorded from tachometer, torque meter and exhaust temperature meter respectively. This process was repeated for all fuel samples

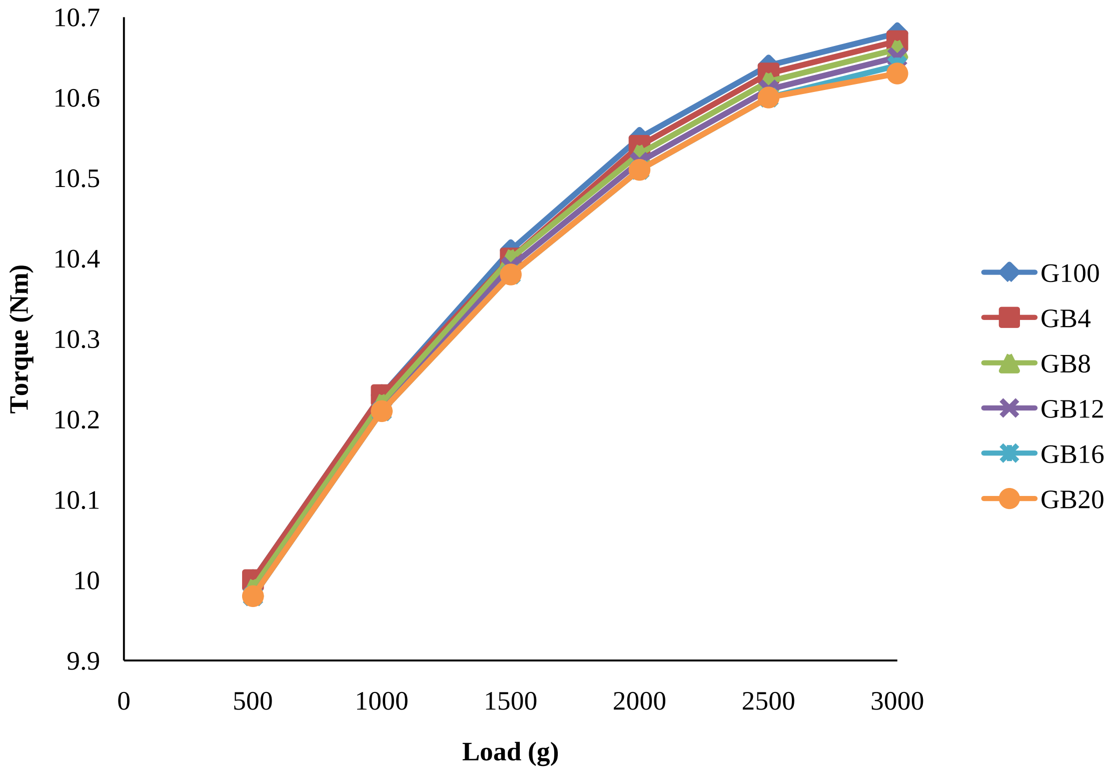
In this work, engine performance was experimentally investigated with pure gasoline and n-butanol-gasoline blends (G100, GB4, GB8, GB12, GB16 and GB20) at 500g, 1000g, 1500g, 2000g, 2500g and 3000g loading conditions. Engine performance test on gasoline fuel was used as a basis for comparison. The properties of the fuels used are shown in the Table 3.1.

3.2 Method of Analysis

The performance of the blends of n-butanol and gasoline as fuel on spark ignition engine at different engine loads were investigated experimentally. The results of experimental engine tests for variation of brake specific fuel consumption, percentage heat loss, air to fuel ratio, torque and brake power versus engine loads are presented in the graph below.

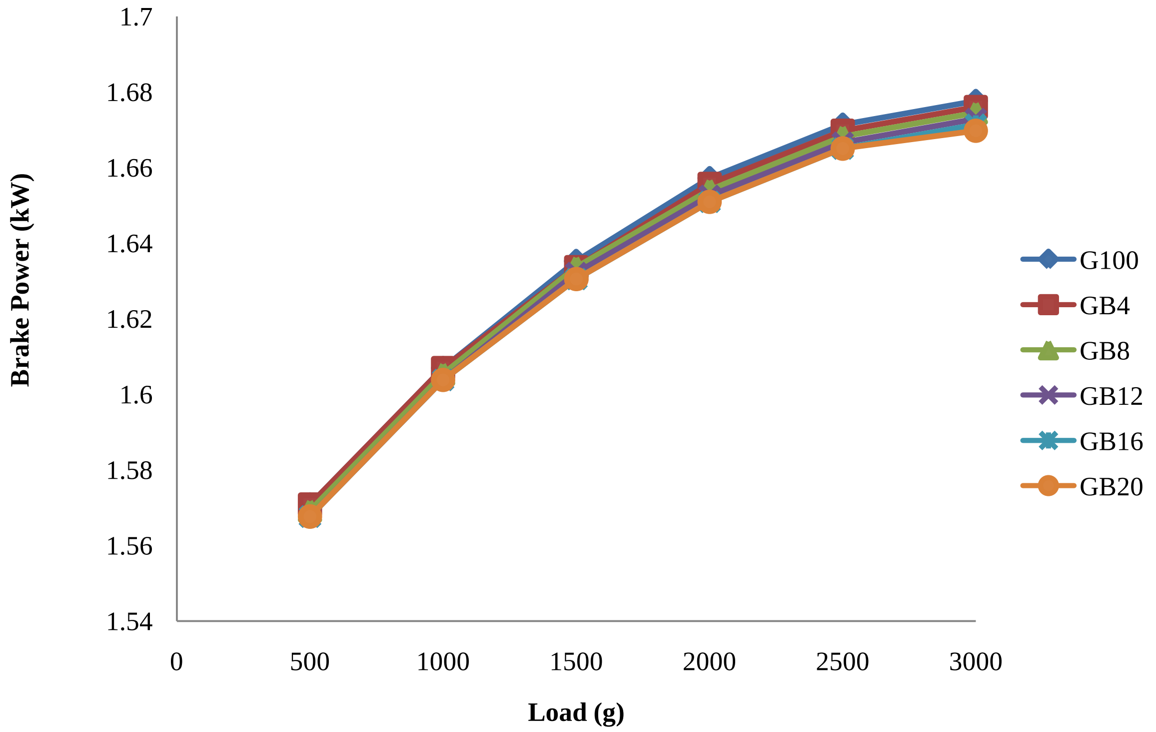
Table 3.1: Properties of the gasoline and n-butanol

Fuel property	Gasoline	n-Butanol
Density at 20 ^{o}C (kg/m^{3})	748	809.6
Kinematic viscosity at 40 ^{o}C (mm^{2}/s)	0.4-0.8	1.2-3.5
Flash point (^{o}C)	-46	35
Calorific value (MJ/kg)	45.4	32.9

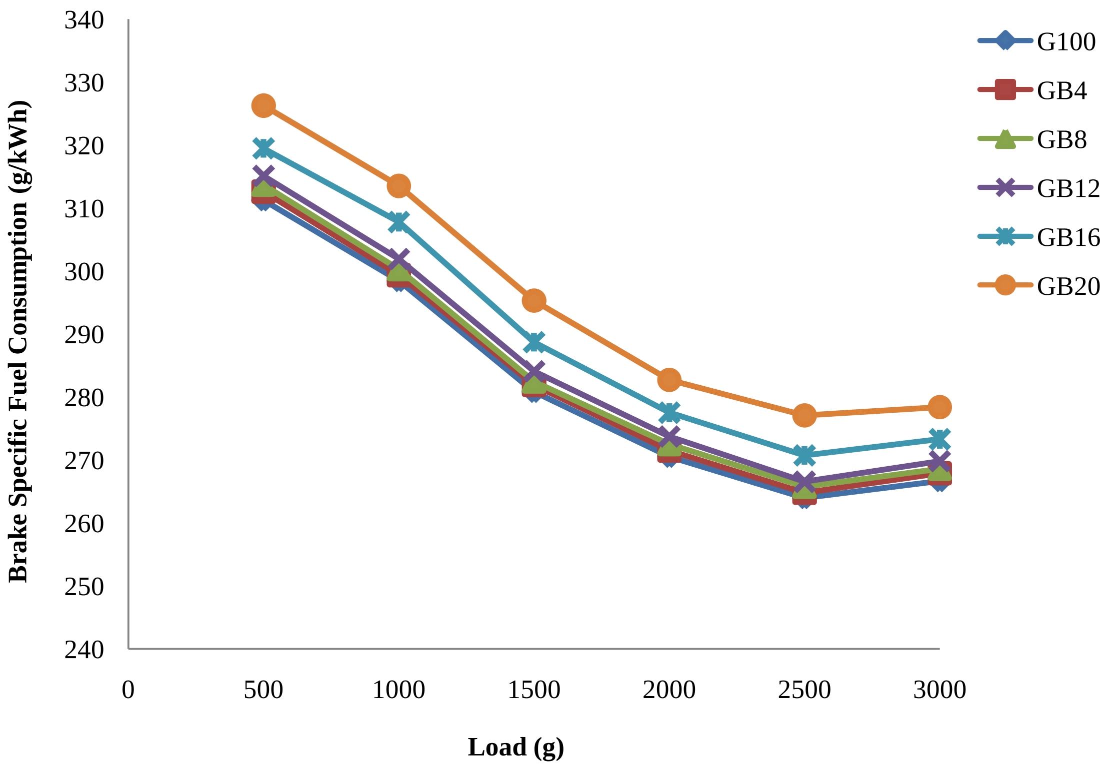


Graph 3.1: Torque for all Fuel Samples with Load Increase

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 245-252 www.ijaem.net ISSN: 2395-5252

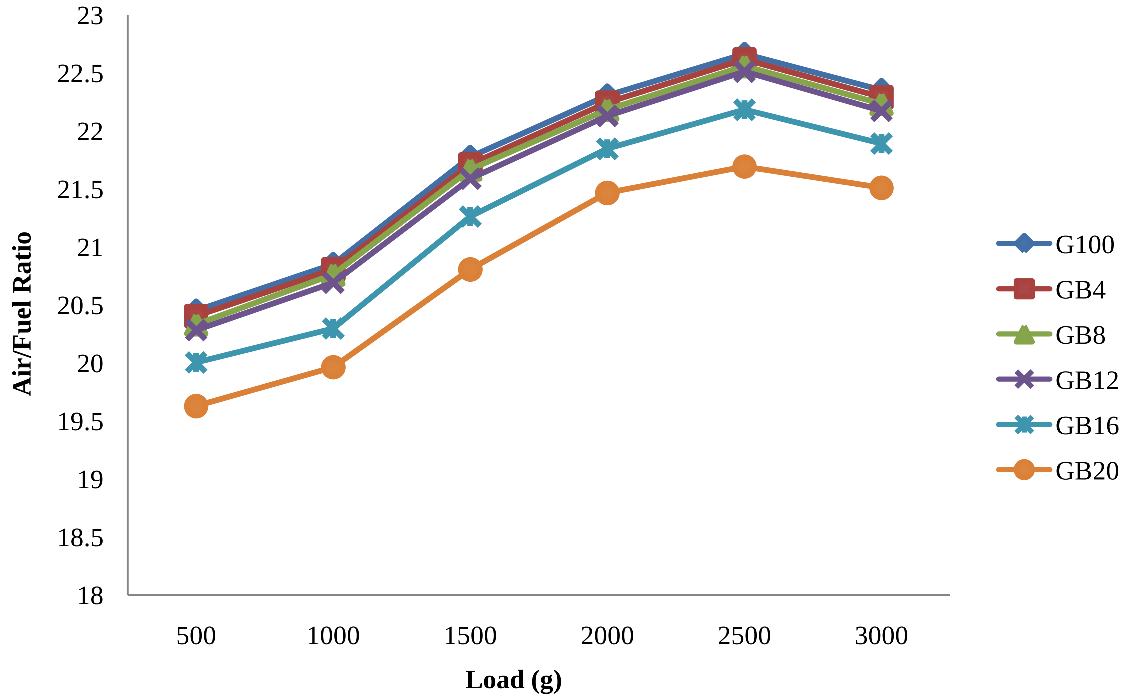


Graph 1.2: P_b for all Fuel Samples with Load Increase

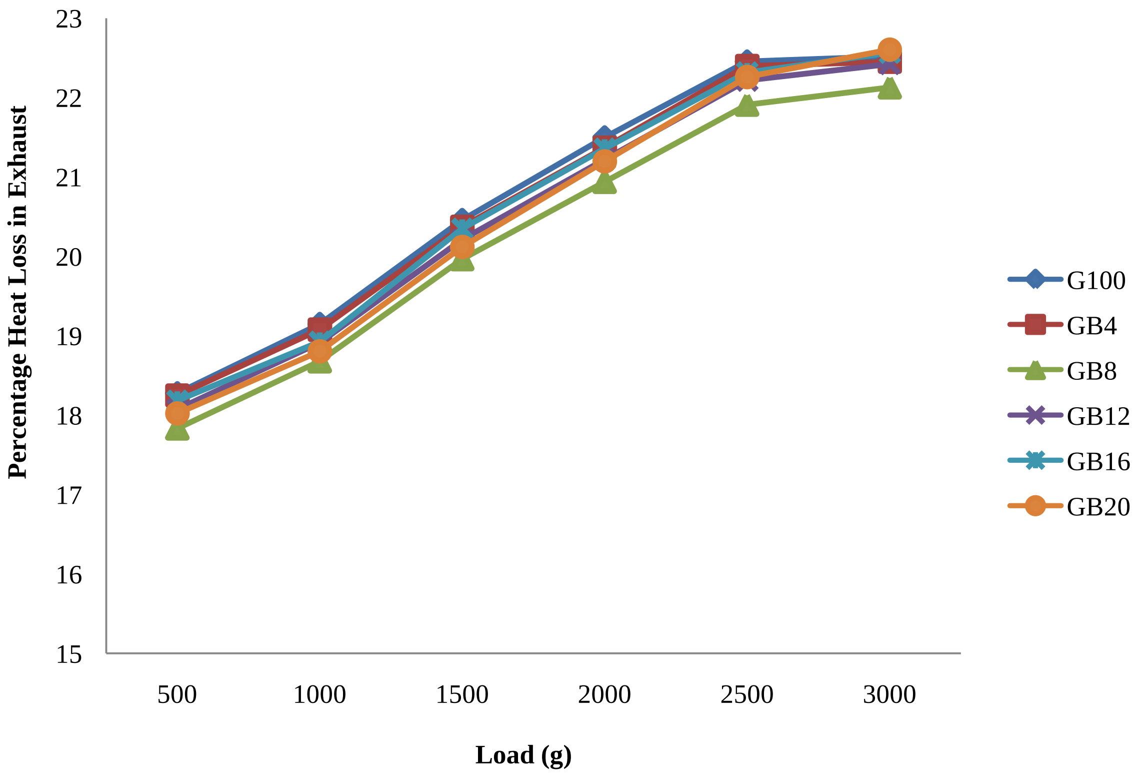


Graph 3.3: BSFC for all Fuel Samples with Load Increase

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 245-252 www.ijaem.net ISSN: 2395-5252



Graph 3.4: A/F for all Fuel Samples with Load Increase



Graph 3.5: PHL in Exhaust for all Fuel Samples with Load Increase

IV. RESULTS ANALYSIS

Torque (τ)

The effect of load on torque for gasoline and the blends are shown in graph 3.1. It was observed that increase in load on the engine, the torque increased for both gasoline and the blends. This was due to increase in fuel consumption with increase in load. Torque drop was observed for the blends in comparison to gasoline as the load increases. Though, it has been observed that addition of n-butanol in gasoline decreases its calorific value (Table 3.1), negligible change in torque can be explained by the oxygen content in n-butanol [9]. Nevertheless, oxygen content of n-butanol improves the combustion in the cylinder, and in turn GB4 and GB8 showed similar torque performance to that of gasoline at loads of 500 g and 1000 g.

This means that the n-butanol absorbs more heat in order to evaporate and burn, and in turn, loose engine torque and power as the n-butanol proportion increases in the blends [10].

Brake power (P_b)

The effect of load on P_b for gasoline and the blends are shown in graph 3.2. It was observed that increase in load on the engine, the P_b increased for both gasoline and the blends. When the P_b of the blends were compared to that of gasoline at different loads, it was found that the P_b of GB4 and GB8 showed similar P_b performance to that of gasoline at loads of 500 g and 1000 g. This could be attributed to their improved calorific values as it combines with gasoline fuel to burn. Whereas that of GB12, GB16 and GB20 are lower than that of gasoline with load increase. This could be attributed to the decrease in the heat released by combustion as a result of lower calorific values of the blends. Since P_b depends on torque, the heat of evaporation of n-butanol is higher than that of gasoline, and that will decrease the power and torque [3].

Brake specific fuel consumption (BSFC)

The variation of BSFC for gasoline and the blends at different loads are shown in graph 3.3. It was observed that as the load increases, BSFC decreases to the minimum at the load of 2500 g, and turns to increases for both gasoline and the blends at load of 3000 g. This improvement in BSFC could be credited to proper burning of the fuel because of presence of oxygen in the blends[11].

The BSFC was found to be higher in all the blends than gasoline. The higher BSFC of the blends could be attributed to the combined effects of lower calorific values and high density of the blends result in high fuel flow rate. Since BSFC was calculated on weight basis, obviously higher densities result in higher values for BSFC [11].

Air/Fuel ratio (A/F)

The variation of A/F ratio for gasoline and the blends at different loads are shown in Figure 5. It was observed that the A/F increases with load increase, and in turn decreases with increase in the concentration of n-butanol in the blends. The A/F mixing process is affected by the atomization of n-butanol due to its higher viscosity. With increase in A/F, the combustion temperatures are lowered and cylinder wall temperatures are reduced, and hence the delay period increases. With increase in load, A/F decrease, operating temperature increase, and consequently, lower the ignition delay period. [12]. The n-butanol addition to gasoline fuel can significantly improve blends combustion due to its partially oxidized nature and a leaning effect caused by its lower stoichiometric A/F, and in turn leads to high A/F higher than the stoichiometric A/F values for all the blends [10].

Percentage heat loss (PHL)

The variation of PHL with load was presented in Figure 9. All the blends showed evidence of lower heat losses in the engine than gasoline. The lower heat loss recorded could be explained in terms of lower calorific 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 [13]. Low exhaust gas temperature and increase in thermal efficiency with increase in blend is an evidence of decrease in heat loss [14].

Conclusion

The engine performance of all the tested fuels with no modification in the engine at various engine loads showed that the use of n-butanol as a fuel additive to gasoline causes slight reduction in the engine performance with increase in blend ratio. Due to the lower calorific value of n-butanol, the brake specific fuel consumption of the blends was higher than that of gasoline. Presence of oxygen in the blends, lower calorific value and increase in fuel density the percentage heat loss of the blends was lower in comparison to gasoline. All the tested fuels performed well in the engine.

Overall conclusion drawn is that the existing fleet of automobiles showing good performance without any modifications in engines the automobile industries.

Acknowledgment

The authors acknowledged the efforts of the staff of the National Centre for Petroleum Research and Development Bauchi, Nigeria, Automotive Engineering Department and Mechanical and Production Engineering Department of Abubakar Tafawa Balewa University Bauchi and Automobile Workshop in the Faculty of Mechanical Engineering, Federal Polytechnic Bauchi and

REFERENCES

[1]. Ramanathan, R. (2000). A Holistic Approach to Compare Energy Efficiencies of Different Transport Modes. Energy Policy. 28, (11), 743.

[2]. Scala, F., Galloni, E., & Fontana, G. (2016). Numerical analysis of a downsized spark ignition engine fuelled by butanol/gasoline blends at part-load operation. Applied Thermal Engineering 102:383-390.

[3]. Elfasakhany, A. (2016). Experimental study of dual n-butanol and iso-butanol additives on SI engine performance and emissions. Fuel 163. 166-174.

[4]. Mack, J. H., Schuler, D., Butt, R. H. & Dibble, R. W. (2016). Experimental investigation of butanol isomer combustion in homogeneous charge compression ignition (HCCI) engines. Applied Energy 165. 612-626.

[5]. Huynh, T. T., Le, M. D. & Duong, D. N. (2019). Effects of butanol–gasoline blends on SI engine performance, fuel consumption, and emission characteristics at partial engine speeds. International Journal of Energy and Environmental Engineering 10:483–492.

[6]. Mourad, M. & Mahmoud, K. (2019). Investigation into SI engine performance characteristics and emissions fuelled with ethanol/butanol-gasoline blends. Renewable Energy 143:762-771

[7]. Saraswat, M. & Chauhan, N. R. (2020). Comparative assessment of butanol and algae oil as alternate fuel for SI engines. Engineering Science and Technology, an International Journal 23: 92–100

[8]. TQ. (2000). TD110-TD115 Test Bed and Instrumentation Manual for Small Engines, TQ Educational and Training Publishers, London. 1-6.

[9]. Campos-Fernandez, J., Arnal, J. M., Gomez, J. & Dorado, M. P. (2012). A Comparison of performance of higher alcohols/diesel fuel blends in a diesel engine. Applied Energy 95. 267-275.

[10]. Elfasakhany, A. (2014). Experimentally study on emission and performance of an internal combustion engine fueled with gasoline and gasoline/n-butanol blends. Energy Conversion and Management 88. 277-283.

[11]. Grabys, J. (2012). Influence of composition of gasoline – ethanol blend parameters of internal combustion engines. Journal of KONES Internal Comb. Engines. 10, 3-4.

[12]. Kalbande, S. R., Pawar, S. N. & Jadhav, S. B. (2007). Production of karanja biodiesel and its utilization in diesel engine generator set for power generation. Karnataka Journal of Agricultural Sciences 20. 680-683.

[13]. Plint & Partners. (1984). Shell- Plint Engine Test Bed Manual. Plint and Partners Publications, England. pp. 8-14.

[14].Siwale, L., Kristóf, A., Bereczky, A., Mbarawa, M. & Kolesnikov, A. (2014). Performance, combustion and emission characteristics of n-butanol additive in methanol–gasoline blend fired in a naturally-aspirated spark ignition engine. Fuel Processing Technology 118. 318-326.