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Performance Study of Dangarfa (Cadaba Farinosa Forskk) - Ethanol Blended Diesel Fuel in Compression Ignition Engine

GAMBO BUHARI ABUBAKAR[1], ROBINSON ICHAKPA EJILAH[2], HABOU DANDAKOUTA[3], AJE TOKAN[4]

[1, 2, 3, 4] Department of mechanical/Production Engineering, Faculty of engineering and Engineering Technology, Abubakar Tafawa Balewa University, Bauchi State Nigeria

Abstract- This paper present engine performance study of blended diesel ethanol derived from Cadaba farinosa forskk plant. The blends were formulated as: BDE2 (97% Diesel and 2% bioethanol volumetric proportion), BDE4 (95% Diesel and 4% bioethanol volumetric proportion), BDE6 (93% Diesel and 6% bioethanol volumetric proportion), DE8 (91% Diesel and 8% bioethanol volumetric proportion) and BDE10 (89% Diesel and 10% bioethanol volumetric proportion) and 1% biodiesel (palm oil methyl esters) was maintained for all the blended test fuel samples to avoid phase separation. on a TD110-115 single cylinder, four stroke and air-cooled, compression ignition engine test rig, under different loading conditions in line with the SAE practice SAE J1312 June 1995 test protocol. The results shows that, a decrease in torque and brake power is due to higher cetane number of biodiesel, the higher calorific value of diesel and that of BDE2 to BDE4 fuel mixtures, as well as complete combustion of fuels. The specific fuel consumption was found to be lower in all blended fuel samples than diesel, and specific fuel consumption decreased up to 83.3% load and increases for all samples. BSFC of all blends were lower than that of diesel and increases with increase in percentage blend. The air -fuel ratio reduces, as the concentration of bioethanol in the blended sample of diesel and bioethanol and engine load increases. However, it shows average difference of 6.18% and 9.4% from the AFR of diesel fuel, BDE2, BDE4 and BDE6 bioethanol-Diesel fuel are 1.78%, 2.24% and 2.81% lower than diesel fuel samples respectively. For all the fuels, the brake thermal efficiency increases with increase in load. This can be attributed to the increase in power with increase in load. For reasons of its satisfactory engine performance behavior, fuel conservation advantages, the candidacy of Cadaba farinosa forssk ethanol and diesel blends, present the prospects of a potential fuel source and diesel fuel extender for compression ignition engines.

Indexed Terms- Cadaba farinosa forssk, engine performance, ethanol, diesel, compression ignition engine.

I. INTRODUCTION

Renewable energy is that energy that is replaced naturally or controlled carefully and can therefore be used without the risk of finishing it all. It is in constant supply without depletion. The world relies heavily on fossil fuels to meet its energy requirements. Fossil fuels such as oil, gas and coal at present provides almost 80% of the total global energy demand while renewable energy (solar, hydro, biomass and geothermal) and nuclear powers are contributes only 13.5% and 6.5% respectively of the total energy needs (1).

It is very important to examine that the alternative fuel used as substitute must be produced from the renewable sources and ways and means should be devised to use this fuel without bringing any modifications in the geometry of the engine. Alcohol has provided an answer to this problem. So Ethanol is well thought-out to be the most fitting fuel for spark Ignition (SI) engines (2).The diesel engines can be operated with substitute fuels such as biomass and it is imperative to use in engines which can be conveyed from vegetable oils and alcohols (3). The purposes of interest on the grounds that renewable energy sources obtained from alcohols and vegetable oils are that may have lower exhaust pollution because of containing the oxygen molecules in their synthetic structure (4). The dependencies on fossil fuel are reduced by the researchers and various efforts are being made to find the alternative economical fuel source. Various researches have contributed towards generating few alternative and cost-effective viable fuels which is also environment friendly (5).

Ethanol produced by fermentation serves considerably as transportation fuel for cars, trucks and trains. The production of ethanol is not limited, but constantly replenished by growing plants and is advantageous over petroleum as a source of fuel in that petroleum source is steadily depleted with usage (6).

1.1 Reasons for Growing Advocacy of Ethanol as Fuel

Even though some fuel properties of ethanol, such as; the octane number, heating value, latent heat of vaporization, flame velocity, specific gravity, Reid vapour pressure and distillation curve, differ from those of diesel. It is nonetheless, crucial to understand the effects of these properties on the performance characteristics of CI engines (7). An ethanol-fuelled engine is less likely to spark off as compared with diesel–fuelled engine as the self –ignition temperature of ethanol is higher than that of diesel at the same compression ratio. This permits for higher detonation-free compression ratio for internal combustion (CI) engines, ensuing higher overall efficiency and shaft power (8). On the contrary, the volumetric efficiency improves with higher heat of vaporization and hence causes more cooling of fresh cylinder charge (9). So ethanol is considered as the most suited fuel and can be readily used in present engines without modifying the engines (10).

Engine power is enhanced abruptly on the usage of ethanol; the sole reason behind this is its octane number which is higher compared to gasoline and diesel fuel respectively. Fuel with higher octane number can undergo a higher compression ratio before blowing off, thus giving the engine the ability to generate more power. Ethanol when considered as a fuel for CI engines had better antiknock characteristics, and burns more cleanly than regular diesel. Its high heat of vaporization helps reduces the peak temperature inside the cylinder and enhances engine power (11). Due to regenerative and ecological characteristics of ethanol, it is extensively used as an alternative fuel at present. The use of diesel containing 3–10 vol % bioethanol is being encouraged for use in IC engines in many parts of the world in the recent past years (12).

1.2 Characteristics of Ethanol-Blended Fuels

Blending ethanol with diesel has multiple effects. Ethanol increases the heat output of the unleaded gasoline, which produces more complete combustion resulting in slightly lower emissions from unburned hydrocarbons. The higher the concentrations of ethanol, the more the fuel has polar solvent-type characteristics with corresponding effects on conducting fire suppression operations. However, even at high concentrations of ethanol, minimal amounts of water will draw the ethanol out of the blend away from the gasoline. Ethanol and gasoline are very similar in specific gravity. The two differing fuels mix readily with minimal agitation, but the blend is more of a suspension than a true solution (13).

II. MATERIALS AND METHODS

2.1 Iternal Combustion Engine Test Bed

The tests were carried out, at the Automotive Laboratory of the Department of Mechanical Engineering, Federal Polytechnic Bauchi-Nigeria, on a TD 110-TD 115 single cylinder four-stroke internal combustion engine test bed compression ignition engine (refer to plate III), and incorporated with a hydraulic dynamometer (refer to table 1 for technical specifications). The engine was operated at a constant speed of 1500rpm and varying load of 500g to 3000g. The same test protocol was used for each set of the blends.

Table 1: Test Engine Characteristics

Parameters	Specifications
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

Source: (TecQuipment TD110-TD115, 2000)

2.2 Blending of the Fuel Samples

The Diesel fuel samples were obtained from NNPC Mega station Bauchi. Blend preparations were produced simply by introducing Diesel/Gasoline, bioethanol and biodiesel constituents into a container and mixing vigorously. Bioethanol blends are denoted as: BDE2 (97% Diesel and 2% bioethanol volumetric proportion), BDE4 (95% Diesel and 4% bioethanol volumetric proportion), BDE6 (93% Diesel and 6% bioethanol volumetric proportion), DE8 (91% Diesel and 8% bioethanol volumetric proportion) and BDE10 (89% Diesel and 10% bioethanol volumetric proportion) and 1% biodiesel (palm oil methyl esters) was maintained for all the fuel samples. 0.5 liters of each of the blends (BDE2, BDE4, BDE6, BDE8, and BDE10 respectively) was prepared. For BDE2, 20ml of ethanol and 1,800ml of Diesel fuel (DF) was measured with a 50ml measuring cylinder and poured into a 200ml beaker. The mixture was stirred thoroughly to produce BDE2 fuel samples. The mixture was allowed to settle for 4-6 hours for miscibility and homogenous consistency.

2.3 Properties of the Blended Samples

The properties of the blended sample of diesel and biodiesel-diesel-ethanol fuels were presented in table below.

Table 2: Fuel properties of diesel and blended fuel samples

Fuel Property	Diesel	BDE2	BDE4	BDE6	BDE8	BDE10
Density (g/m^3)	830	869	862	858	855	851
Specific gravity	0.83	0.869	0.862	0.858	0.855	0.851
kinematic viscosity (mm^2/s)	2.85	4.92	4.51	4.13	3.82	3.53
Calorific value (MJ/Kg)	43.4	39.6	39.2	38.7	38.2	37.8
Flash point ℃	76	24	25	26	27	28
Pour point ℃	6	-5	-7	-10	-14	-18
Cloud point ℃	4	4	4	4	4	4

2.4 Experimental Procedure

The samples of diesel and the blends of BDE2, BDE4, BDE6, BDE8 and BDE10 were tested in the engine test bed at varying load of 500g-3000g and constant speed of 1500rpm to know the performance of the blends. Various values of brake torque, time taken to consume 8ml of fuel, exhaust temperature and air flow manometer readings were taken. The was carried out in line with the SAE practice SAE J1312 June 1995 test protocol

III. RESULTS AND DISCUSSION

3.1 Engine Performance Parameters Results

The brake torque, brake power, brake specific fuel consumption, brake thermal efficiency, and air fuel ratio of the diesel and the blends were computed using excel spreadsheet. Figures 2 to 6 shows the variation of Torque, brake power, brake specific fuel consumption, air fuel ratio and brake thermal efficiency of diesel, and the various blends with varying load and constant speed.

3.1.1 Torque

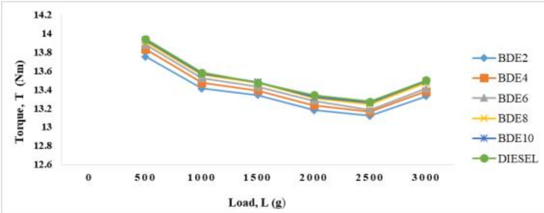

Fig. 2: Variation of Torque for the Diesel and the Blends with Increase in Load

The relationship between the load and the torque for various fuels is presented in Figure 2. It was observed that as the load increases, torque also decreases. This too could be explained in terms of higher fuel consumption as a result of increase in load. When the torque produced by the engine at different loads for the diesel fuel and mixtures of dual fuels were compared, it was found that the torque decreases to the maximum at 2500g load and then it increases for all the fuel samples. The increase in torque is attributable to higher cetane number of biodiesel, the higher calorific value of diesel and that of the dual fuel mixtures from BDE2 to BDE4, as well as complete combustion of fuels. The torque and brake power produced in case of BDE2 and BDE8 were 0.1 to 13% and 0.1 to 14% lower than that of diesel respectively, due to complete combustion of fuels. In case, BDE8 to BDE10, the brake power and torque reduced by 4 to 23% from that of diesel due to decrease in calorific value of fuel with increase in biodiesel percentage in the blends.

3.1.2 Brake Power

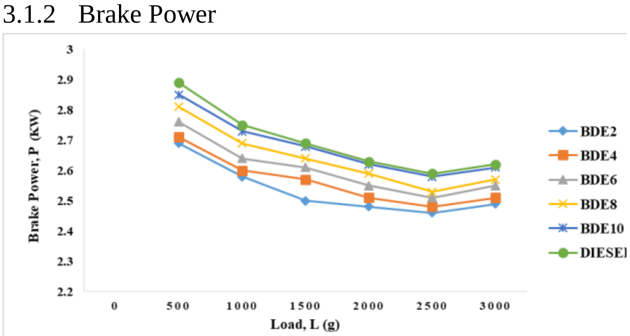

Fig. 3: Variation of Brake Power for the Diesel and the Blends with Increase in Load

The influence of load on brake power for different fuels is presented in Figure 3. It was observed that as the load increases, brake power decreases to the maximum at 2500g load and then increases for all the fuel samples. 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 BDE2, BDE4, BDE6 and BDE8 are lower than that of diesel. However, the higher brake power generated by bioethanol-diesel fuel blends could be attributed to their improved calorific (heating) value as it combines with conventional diesel fuel to burn. The brake power of BDE10 is almost the same with that of diesel. Since brake power depends on torque, with higher proportions of bioethanol, the torque produced is less due to lower amount of energy released caused by increased lubricity of biodiesel in the blend.

3.1.3 Brake Specific Fuel Consumption

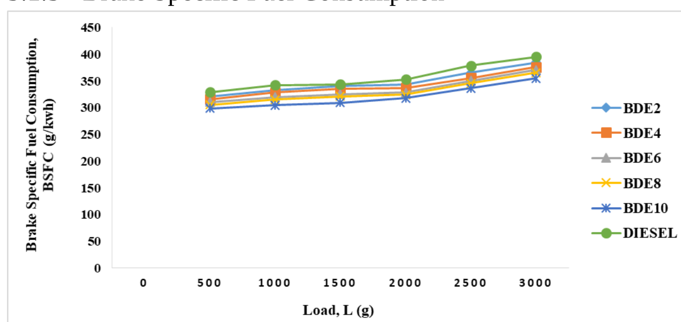

Fig. 4: Variation of Brake Specific Fuel Consumption for the Diesel and the Blends with Increase in Load

Figure 4, shows the variation of brake specific fuel consumption of diesel and various blends of bioethanol and diesel oil at different loads. It was observed that as the load increases, brake specific fuel consumption decreases to the minimum at 2000g load and then starts to increases for all the fuel samples tested. This improvement in BSFC was perhaps due to better combustion of the fuel, which may be attributed to the presence of oxygen in the blend. The specific fuel consumption was found to be lower in all blends than diesel. The higher BSFC of biodiesel blends could be attributed to the combined effects of lower heating value, and the higher fuel flow rate due to higher density of the fuel blends. It was also observed that while increasing the load of the engine, the SFC will be reduced for all the fuels. However, under full load condition, the SFC of biodiesel was found to be lower than that of diesel for reasons of the higher specific gravity and lower calorific value of the biodiesels in comparison with diesel fuel.

3.1.4 Brake Thermal Efficiency

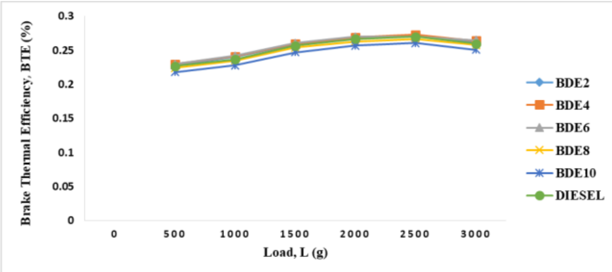

Fig. 5: Variation of Brake Thermal Efficiency for the Diesel and the Blends with Increase in Load

The variation of brake thermal efficiency with load is shown in Figure 5. For all the fuels, the brake thermal efficiency increases with increase in load. This can be attributed to the increase in power with increase in load. The initial increase in BTE may also be credited to the complete and high combustion of fuel, but once the load reached 2500g; the time taken for complete combustion of fuel was decreased and a slight drop in BTE ensured, as could be observed from Figure 5. Oxygen present in the blends also helped in complete combustion of fuel under low load conditions. The brake thermal efficiencies of BDE2, BDE4 and BDE6 are higher than that of diesel at all loads with BDE6 having the highest value, while those of BDE8 and BDE10 were less than that of diesel. This lower brake thermal efficiency could be due to the reduction in calorific values, and increase in fuel consumption as compared to BDE2, BDE4 and BDE6. The decrease in brake thermal efficiency with increase in blend concentration is caused by the poor atomization of the blended fuel samples due to their higher viscosities.

3.1.5 Air Fuel Ratio

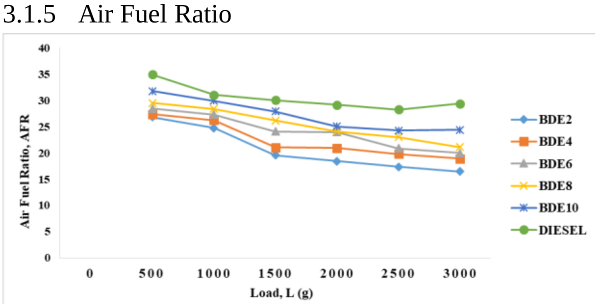

Fig. 6: Variation of Air Fuel Ratio for the Diesel and the Blends with Increase in Load

Figure 6 in turn, shows the variation of air-fuel ratio with load for all tested samples. In C.I engines at a given speed the air flow do not vary with load, it is the fuel flow that varies directly with load. It could be seen from figure 29, that as the percentage blend increases, the air fuel ratio decreases but increases with increase in load. Air-fuel ratio values of bioethanol blends are less than diesel. Except for BDE8 and BDE10 bioethanol-diesel fuel blends, which demonstrated an average difference of 6.18% and 9.4% from the AFR values for diesel fuel, BDE2, BDE4 and BDE6 bioethanol-Diesel fuel blends with a corresponding difference of 1.78%, 2.24% and 2.81% values lower than the diesel fuel benchmark respectively. The observation made from this finding is that all tested fuel samples reached maximum power output and torque at slightly higher than the stoichiometric AFR values (i.e. 18-25) for compression ignition engines.

IV. CONCLUSION

From the foregoing study, the following could be concluded:

1 The decrease in torque and brake power is due to higher cetane number of biodiesel, the higher calorific value of diesel and that of BDE2 to BDE4 fuel mixtures, as well as complete combustion of fuels.
2 The specific fuel consumption was found to be lower in all blended fuel samples than diesel, and specific fuel consumption decreased up to 83.3% load (2500g) and increases for all samples. BSFC of all blends were lower than that of diesel and increases with increase in percentage blend.
3 The air -fuel ratio reduces, as the concentration of bioethanol in the blended sample of diesel and bioethanol and engine load increases. However, it shows average difference of 6.18% and 9.4% from the AFR of diesel fuel, BDE2, BDE4 and BDE6 bioethanol-Diesel fuel are 1.78%, 2.24% and 2.81% lower than diesel fuel samples respectively.
4 For all the fuels, the brake thermal efficiency increases with increase in load. This can be attributed to the increase in power with increase in load.
5 Diesel-Cadaba farinosa forssk ethanol biodiesel blended fuel samples performed satisfactorily on Compression-ignition engines without any engine hardware modification and this further lends credence to the candidacy of ethanol derived from

Cadaba farinosa forssk shrub as fuel –or fuel extender for compression ignition engines.

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