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Performance and Emission Characteristics of a Diesel Engine Using Jatropha Oil – Diesel Blends

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Abstract

The purpose of this study is to investigate the performance and emission characteristics of a diesel engine using Jatropha oil-diesel blends (J10, J15 and J20 with 10%, 15% and 20% Jatropha oil respectively). Fuel properties for the blends were studied and compared with pure diesel fuel. The performance and emission characteristics were tested on a diesel engine (four stroke, four cylinders, indirect injection fuel system with Intercooler and Turbocharger). Fuel test results showed that blends densities for J10, J15 and J20 were 3.74%, 4.22% and 4.70% respectively, higher than that of diesel fuel. The kinematic viscosity for blends was 62.92%, 88.6% and 110.8% respectively, higher than that of diesel fuel. Calorific value for blends was reduced by 1.72%, 1.85% and 1.98% respectively relative to the value for diesel fuel. Flash point for blends was 17.5%, 45% and 77.5% higher than of diesel fuel. The engine power output and torque, for tested blends, increased at low engine speed (1600 rpm), but at higher speed (2200 rpm) decreased relative to diesel. Fuel consumption slightly increased for blends at both speeds. Brake thermal efficiency for blends increased at higher engine speed (2200 rpm), but at lower speed (1600 rpm) was less than diesel. There was also a slight increase in exhaust emissions (CO, NO, NO_x, SO_2) for blends at lower speeds however was less than diesel at medium and higher speeds.

Keywords

Jatropha Oil-Diesel Blends, Engine Performance, Fuel Characteristics

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1. Introduction

The increasing demand for petroleum based fuels, global warming and environmental pollution has driven the world to search for newer, safer, cheaper and cleaner sources of fuel. In Sudan, a major problem for rural areas is the inadequate supply of power for lighting, heating, cooking, cooling, water pumping, radio or TV communications and security services. Petroleum product supplies, including diesel, kerosene and LPG are irregular and often subject to sudden price increases [1]. Per capita consumption of diesel fuel in the Sudan in 2009, according to World Bank data is 36 liters. According to the total consumption of diesel fuel in the Sudan in 2009 is 1112 million liters. The annual bill for consumption of diesel fuel in Sudan was estimated about 478.16 million dollars.

Jatropha Curcas is shrub or small tree that grows to a height of 3-5 meters and sometimes, when suitable climatic conditions prevail, grows up to 8-10 meters. The tree is affiliated to the herbaceous plants, and its leaves resemble grapes' fruits and its fruit is in the form of a nut, the size golf ball, containing seeds that produce bitter taste oil [2]. Jatropha Crucas is a good crop and can be obtained with little effort. Depending on soil quality and rainfall, the kernels consist of oil to about 60 percent; this can be transformed into biodiesel fuel through transesterification. Jatropha Curcas grows almost anywhere, even on gravelly, sandy and saline soils. It can thrive on the

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poorest stony soil. Jatropha Curcas is found in the tropics and subtropics and likes heat, although it does well even in lower temperatures and can withstand a light frost. Its water requirement is extremely low and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. Jatropha is also suitable for preventing soil erosion and shifting of sand dunes [3].

Sudan is a large agricultural country with various climates differs from arid in the north to dry savanna climate in the south. Sudan has the longest river and the tributaries between the third world countries. Diversity of climate resulted in producing different oil seeds (peanut, sesame, sunflower, cotton seed and watermelon seed. some other oil seeds such as Jatropha, castor, bitter melon, Roselle, laloub and some melon seeds. This latest seeds are used in producing biodiesel. Sudan lands are suitable for Jatropha plantation as the plant grows naturally as native plant in many regions there. Middle and South of the country is best conditions for Jatropha to grow [3]. Jatropha is found in Sudan in many areas such as Khartoum State in Central Sudan, Kassala State in the East and Kordofan State in the West. However, it is dominant in the Southern States especially in Bahr El Jebel and Bahr El Gazal States. It is mentioned as an indigenous plant in some books describing the plants of Sudan. The farmers in the south plant them as hedges to protect their gardens and fields.

Jatropha Project exists in Kutum, North Darfur, with participation of the German Development Service. The experimental and pilot project, known as Kutum was launched in North Darfur with participation of a German research center, was all but success. The pilot project has proved that although Jatropha is an equatorial plant, it still can grow in all types of soils found in the Sudan [2]. Presently, Ministry of Sciences is executing project for biofuel production in Sudan, which Northern State has embarked on its implementation through HOI-Mea holding company, a branch of Saudi based Bagshan Group, to cultivate Jatropha plant in area of 250 feddans in the region of Nubi Lake, 75 km west of the Nile, 180km north-east of Northern State capital Dongola.The project is aimed at cultivating 259 feddans of Jatropha, recently 145,000 plants have been cultivated in an area of 63 feddans because water network is ready for trickle irrigation and that efforts are ongoing to import new types of seeds adaptable to desert climate. Jatropha cultivation project has started in 2010, disclosing that water is available in accordance with mineral water European standards without treatment. The water has the characteristics of being extracted under normal temperatures not 10°C.

The Jatropha annual production of seeds is around six to twelve kilograms, of which oil constitutes 25%, and the remaining part is subject to other medical uses in addition to soap making and some types of glycerine and fertilizers. The Jatropha tree have age 40-50 years with annual production not less than 8 kilograms. The directors of the projects are planning to generalize Jatropha to the Sudanese farmers to be grown side by side with groundnuts, sesame and gum Arabic [4]. The study aims to investigate the performance and emission characteristics of a diesel engine using Jatropha oil-diesel blends. Specific objective are:

1. To evaluate physical properties of Jatropha oil-diesel blends such as density, viscosity, flash point, calorific value, cloud point and ash content and compare them with diesel fuel.
2. To investigate engine performance parameters such as fuel consumption, brake power and brake thermal efficiency and compare them with diesel fuel.
3. To inspect the components of exhaust gases such as NO, CO, NOX, and SO_2 and compare them with that from diesel fuel.

2. Literature Review

2.1. Introduction

The most important factors determining the performance and emissions of fuel in an internal combustion engine are listed as follows: Brake Thermal Efficiency, Brake Specific Fuel Consumption, Volumetric Efficiency, and exhaust gas emissions.

In the U.S., the standard specification for diesel fuel oils is ASTM D 975 which contains a set of physical, chemical, and performance specifications, established by the Society to meet the approval requirements of ASTM procedures and regulations (Table 1).

Table 1. Diesel fuel properties – ASTMD975 [5].

Blend property	Units	Value
Density @ 15.5°C	kg/L	0.85
Kinematic Viscosity @ 40°C	mm^2/s	1.3 – 4.1
Flash point	°C	60 – 80
Cloud point	°C	-35 to 5
Pour point	°C	-35 to -15
Heating Value	MJ/kg	45.4

Several operating characteristics influence engine performance, and their relative importance depends on engine type and duty cycle (for example, truck, passenger car, stationary generator, marine vessel, etc.). These characteristics are starting ease, low noise, low wear (high lubricity), long filter life (stability and fuel cleanliness), sufficient power, good fuel economies, low temperature operability, low emissions and smoke.

The three most important factors affecting engine performance are:

1. Sufficient power: power is determined by the engine design. Diesel engines are rated at the brake horsepower developed at the smoke limit for a given engine; varying fuel properties within the ASTM D 975 specification range does not alter power significantly. However, fuel viscosity outside of the ASTM D 975 specification range causes poor atomization, leading to poor combustion, which leads to loss of power.
2. Fuel Economy: Here again engine design is more important than fuel properties. However, for a given engine used for a particular duty, fuel economy is related to the heating value of the fuel. Heating value per volume is directly proportional to density when other fuel properties are unchanged. Each degree increase in American Petroleum density equates to approximately two percent decrease in fuel energy content.
3. Low emissions: Variation of most fuel properties within the normal ranges will not lead to the high level of particulate matter (PM) represented by smoking. The exception is Cetane number; fuel with a very high Cetane number can cause smoking in some engines. The short ignition delay causes most of the fuel to be burned in the diffusion-controlled phase of combustion which can lead to higher PM emissions. Some efforts of adding pollution control systems to vehicles and reformulating fuels paying off in better air quality.

2.2. Performance of Pure Vegetable Oil

Bruwer et al. [6] studied the use of sunflower seed oil as a renewable energy source. When operating tractor with 100%sunflower oil instead of diesel fuel, an 8% power loss occurred after 1000 h of operation, which was corrected by replacing the fuel injector and injector pump. Yarbrough et. al. (1981) reported that raw sunflower oils were found to be unsuitable fuel, while refined sunflower oil was found to be satisfactory.

Schoedder [7] obtained mixed results using rapeseed oils as a diesel fuel replacement in a series of studies. Although short-term engine tests indicated that rapeseed oil had similar energy outputs compared to diesel fuel, the results of long-term engine tests revealed operating difficulties arising from deposits on piston rings, valves and injectors, particularly after 100 hours of continuous operation.

Reid et al. [8] conducted injection studies and engine tests to evaluate the chemical and physical properties of 14 plant oils related to their use as Alternative fuels. The injection studies showed that the plant oils dispersed differently compared to diesel fuel due to their much higher viscosities. The engine tests showed that the level of carbon deposit varied even for plant oils with nearly similar viscosities, indicating that oil composition was also an important factor. The tests also revealed that pre-heating the oil prior to injection could reduce the amount of carbon deposits in the engine.

Ragu et al. [9] compared the brake specific fuel consumption (BSFC) of preheated Rice bran oil and Rice bran oil without preheated the former has a lower BSFC as compared to the later. This is due to the improvement in viscosity that leads to better atomization in the case of preheated Rice bran oil. At all loads the engine with diesel operation shows a higher efficiency and with Rice bran oil it shows a lower efficiency. The preheated Rice bran oil operation shows efficiency higher than oil without preheating. At a given load the diesel has lower value and Rice bran oil shows a higher value of exhaust gas temperature. The preheated Rice bran oil has a lower exhaust gas temperature as compared to Rice bran oil at all loads

2.3. Performance of Jatropha Oil Blends

Chalatlon et al. [10] reported on a non-edible vegetable oil produced from Jatropha fruits as a substitute fuel for diesel engines. Their study examined its usability and was investigated as pure oil and as a blend with petroleum diesel fuel. A direct injection (DI) diesel engine was tested using diesel, Jatropha oil and blends of Jatropha oil and diesel in different proportions. A wide range of engine loads and Jatropha oil/diesel ratios of 5/95% (J5), 10/90% (J10), 20/80% (J20), 50/50% (J50), and 80/20% (J80) by volume were considered. J5 showed slightly higher thermal efficiency than diesel. J10 and J20 showed similar thermal efficiency, but J50 and higher blends showed 3 to 5% less thermal efficiency than diesel fuel. The observation is that the higher the Jatropha oil in the blends, the higher the reduction in the thermal efficiency. The reasons might be explained as follows: Due to very high viscosity and low volatility of Jatropha oil, higher Jatropha oil blends suffer from worse atomization and vaporization followed by inadequate mixing with air. The consequence is inefficient combustion. This suggests that high fuel injection pressure and improved volatility might be helpful for better combustion with higher thermal efficiency for higher Jatropha blends. (J5) blend shows about 3% less BSFC in average than diesel fuel. The deterioration in BSFC up to J20 is 1.5 to 3.4%. J50, J80, and pure Jatropha oil show average BSFC deterioration of about 10, 15 and 25%, respectively. The lower the loads lead to the higher the deterioration in the BSFC. At low load conditions, the cylinder temperatures are low. Due to poor volatility of pure Jatropha oil, low cylinder temperature at low load conditions might not favour proper combustion. J5 produced about 50% more CO than diesel throughout the operation. J10 and higher blends produced about double the CO when compared to diesel. Emissions of CO_2 with Jatropha oil blends up to moderate loads are lower than that with diesel fuel. When the load was 50% or higher J50 and higher blends produced about 20% CO_2 higher than diesel.

Other experimental investigations have been carried out to analyze the performance characteristics of a compression ignition engine from the blended fuel (5%, 10%, 20% and 30%). Crude Jatropha oil blend's power values were lower than diesel fuel. This lower engine power obtained for blended crude Jatropha oil could be due to higher density and higher viscosity of Jatropha oil. J5 proved to be almost similar to diesel which provides higher brake thermal efficiency value than others. As a result of the higher viscosity, the thermal efficiency is lower with blended crude Jatropha oil as compared to diesel. The air fuel ratio is found to increase with the increasing of the concentration of the blended crude Jatropha oil in all internal combustion engines. As concluded for this study, Brake Specific Fuel Consumption and air fuel ratio for all blended crude Jatropha oil composition were found to be higher compared to diesel. The value for the Torque, Brake Power, Brake Mean Effective Pressure and Thermal efficiency were lower for all blended crude Jatropha oil composition compared to diesel [11].

3. Materials and Methods

3.1. Introduction

Fuel properties experiments were carried out in Center Petroleum Laboratory, Ministry of Electricity and Dams. While engine performance and emission tests were carried out in a diesel engine, Thermo laboratory at Faculty of Engineering, Sudan University of Science and Technology.

3.2. Extraction of Jatropha Oil

Jatropha seed were obtained from the Biodiesel department in the Energy Research Institute (15kg of Jatropha seeds) and from the Africa City of Technology (10kg of Jatropha seeds). Jatropha seeds were then pressed by screw-press, at the Omdurman oil market, resulting in a yield of 1 litter or 0.88 kg Jatropha oil. The low extraction ratio of oil is mainly due to the low efficiency of the machine used and the long time for storage after harvesting.

3.3. Blends Sample Preparation

The first sample of blend J10 was prepared by mixing 200 ml Jatropha oil with 1800 mL diesel. The second sample of blend J15 was prepared by mixing 300 ml Jatropha oil with 1700 ml diesel. Finally, the third sample J20 was prepared by mixing 400 ml of Jatropha oil with 1600 ml of diesel.

3.4. Equipment for Blends Properties Tests

The samples properties were inspected at Central Laboratory for Science, Environmental and Soil Research (Sudanese Company for Electricity Distribution/ Ministry Of Electricity And Dams). The viscometer was used to determine the viscosity of Jatropha oil-diesel blends. The cloud point of blends was inspected by cloud point test tube. The flash point of the blends was measured by Pensky-Martens closed cup test.

3.5. Tests Equipment

The experimental setup used in this study consists of an internal combustion engine Mitsubishi cyclone motor model 4D56_JG3553.The 4D5 engine is a range of four-cylinder belt-driven overhead camshaft diesel engines. The specification for the engine is shows in table 2.

Table 2. Engine Specifications.

Engine name	**Mitsubishi cyclone motor Intercooled Turbo (TD04 water cooled Turbo)**
Model	4D56, JG3553
Displacement	2.5 L (2,476 cc)
Bore	91.1 mm
Stroke	95.0 mm
Fuel type	Diesel
Power	78 kW (104 hp) at 4,300 rpm
Torque	240 N·m (177 lb·ft) at 2,000 rpm
Engine type	Inline 4-cylinder
Rocker arm	Roller Follower type
Fuel system	Distribution type jet pump (indirect injection)
Combustion chamber	Swirl type
Bore x Stroke	91.1 x 95mm
Compression ratio	21:1
Lubrication System	Pressure feed, full flow filtration
Intercooler Type	Aluminium Air to Air, Top-mounted
Turbocharger	Mitsubishi TD04-09B

The engine is coupled with a hydraulic dynamometer. A dynamometer was used to load the engine at known speeds. The dynamometer cycle consists of a water pump, water tank, pipes, valves and brake turbine.

3.6. Flue Gas Analyzer

EcoLine Portable industrial flue gas analyzer was used for monitoring NO_X, SO_X, CO_X hydrocarbons and H_2S. EcoLine 6000 consists of two functional parts: the gas analysis unit and the remote control unit (RCU).Communication between the two devices is via standard RS232. All data collected by the analysis unit is sent to the RCU to be viewed, stored and printed. Gas analysis unit includes an aspiration pump, filters, condensate drain with peristaltic pump, cells and electronics.

3.7. Experimental Procedure

The experimental procedure is as follow:

1. The amount of fuel level is checked in the outer tank where the amount of the sample is two litters. The engine cooling water is checked together with the engine lubrication and the dynamometer water level.
2. The engine is operated unloaded. The speed is gradually increased to 1600 rpm and the weight of fuel sample is recorded in kg. The weight is again recorded after 30 seconds, for purpose of knowing the fuel consumption. The Gas sampling probe is fixed to the out let of the engines exhaust for 30 seconds. The composition of the exhaust gas fumes (NO, NO_2, NO_X, CO, SO_2) is recorded
3. Step no. 2 is then repeated at the engine speeds of 1800, 2000, 2200 rpm for the three fuel samples
4. The engine is loaded at the speed of 1600 rpm till the engine is about to stop. Fuel consumption during 30 seconds is recorded together with the composition of the exhaust gas fumes. The torque on the engine is also recorded
5. Step no. 4(5) is repeated at the engine speed 2200 rpm for the three fuel blend samples

4. Results and Discussion

The results of blends fuel properties, engine performance and emission are presented and discussed in the following sections

4.1. Physical and Chemical Properties Determination

Standard methods (ASTM and Crakel Test) were used to determine the properties of the Jatropha oil blends at the Central laboratory for Science, Environment and Soil Research (Sudanese Company for Electricity Distribution (Ministry of Electricity and Dams)). Summary of chemical and physical properties of the Jatropha oil blends (J10%, J15%, J20%) are provided in Table 3.

The data obtained from inspection of various sample blends indicated an increase in density with an increase in Jatropha oil concentration. This increase caused by high density of pure Jatropha oil. The viscosity of fuel blend increased with increase in the concentration of Jatropha oil in the blend. By comparison with diesel viscosity the influence of Jatroph oil in the viscosity rise is very clear. The rise in viscosity results from high Jatropha oil viscosity that reached to (50.73 mm^2/s).

Flash point of the fuel blend Jatropha oil and diesel obviously increases with increase in content of Jatropha oil in the blend. This increase is caused by low volatility of pure Jatropha oil. The Cloud Point to be constant at low blending ratios of Jatropha oil with diesel fuel but compared with cloud Point of diesel fuel is evident influence of Jatropha oil in raise a cloud point of fuel blend due to the high viscosity of pure Jatropha oil.

Increasing content of Jatropha oil in the fuel sample resulted in a decrease in the calorific value of the fuel. The calorific value of Jatropha oil and diesel blend at a blending ratio of 20% reaches to 45.09 MJ/kg in comparison with calorific value of pure diesel fuel this equivalent 46 MJ/kg.

Table 3. The chemical and physical properties summarize of the Jatropha oil-diesel blends.

Fuel Property	Diesel	J10%	J15%	J20%
Density @ 15°C, kg/L)	**0.85**	**0.860**	**0.864**	**0.868**
Kinematic Viscosity @ 40°C(mm^2/s)	2.4	3.91	4.526	5.059
Flash point (°C)	40	47	58	71
Cloud Point (°C)	-34	11	12	11
Ash Content (% wt)	0.01	0.009	ND	0.005
Colorific Value (kJ/kg)	46,000	45,208.6	45,148.2	45,090.56

4.2. Engine Performance

The engine performance was initially investigated without load and the specific fuel consumption was calculated (Figure 1). The increase in the concentration of Jatropha oil in the blend leads to increased fuel consumption especially at small and medium speeds, but at high speeds is less than diesel. The high viscosity of higher blends which cause fuel injection delay.

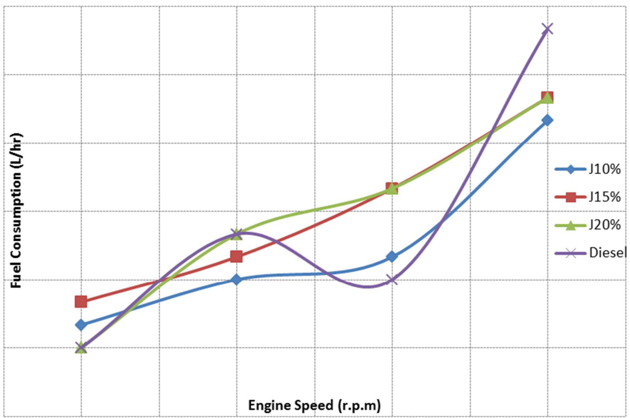

Figure 1. Specific Fuel Consumption.

The engine was loaded at two speeds 1600 and 2200 rpm to determine the engine performance at lower and higher loading. The following engine parameters were computed with the engine under load:

(a) Brake specific fuel consumption

(b) Brake power

(c) Brake thermal efficiency

Table 4 shows the variation of brake power with torque. The brake power slightly increases with an increase of engine torque. It is evident the effect of Jatropha oil leads to loss in engine power.

Table 4. The variation of Brake Power versus Torque.

Engine speed	1600 rpm		2200 rpm	
Type of Fuel	Engine Torque (N.m)	Brake Power (kW)	Engine Torque (N.m)	Brake Power (kW)
Diesel	90	16.25	110	25.34
J10%	92	15.41	99	22.81
J15%	92	15.41	100	23.04
J20%	95	15.92	102	23.50

The variation of brake thermal efficiency with torque listed in table 5. Note the effect of the concentration of Jatropha oil in the blend is negative and lead to lower efficiency of the engine at low loading but at higher loading the blends are more effective than diesel. This is probably due to the increase in cylinder temperature at higher loading.

Table 5. The variation of Brake thermal efficiency versus Torque.

Engine speed	1600rpm		2200rpm	
Type of Fuel	Engine Torque (N.m)	Brake thermal efficiency%	Engine Torque (N.m)	Brake thermal efficiency%
Diesel	90	33.12	110	42.38
J10%	92	33.98	99	45.71
J15%	92	33.42	100	46.49
J20%	95	34.44	102	45.03

The variation of brake fuel consumption with load is shown in Table 6. Increase in the concentration of Jatropha oil in the fuel blend leads to an increase in fuel consumption.

Table 6. The variation of Brake fuel consumption versus Torque.

Engine speed	1600rpm		2200rpm	
Type of Fuel	Engine Torque (N.m)	Brake fuel consumption (L/hr)	Engine Torque (N.m)	Brake fuel consumption (L/hr)
Diesel	90	5.33	110	6.5
J10%	92	5	99	5.5
J15%	92	6.17	100	5.5
J20%	95	5.17	102	5.83

4.3. Engine Emissions

Exhaust gases were analyzed for the blends to identify the impact of the following cases:

1. The engine running without load
2. The engine running under load

4.3.1. Emissions of Engine Running Without Load

The relation between CO values and angular speed of engine is presented in Figure 2. The decline in the values of CO in fuel blend combustion outcomes is observed with high concentration of Jatropha oil especially at upper speeds of the engine. The amount of CO expected decrease with an increase in the content of Jatropha oil in the blend.

Figure 3 shows the change in the volume of nitrogen monoxide emission with engine speed. The values of nitrogen monoxide resulting from the combustion of diesel are greater than that resulting from the combustion of fuel blend Jatropha oil and diesel especially at higher speeds. The late fuel injection caused incomplete combustion due to the higher viscosity of Jatropha oil.

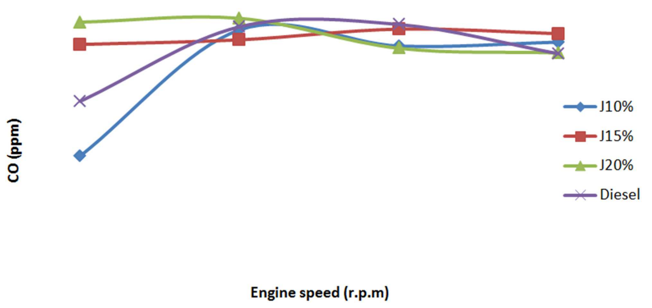

Figure 2. Carbon Monoxide Emission.

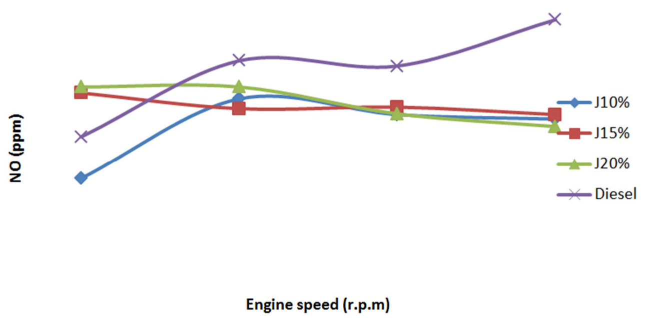

Figure 3. Nitrogen monoxide emission.

Figure 4 shows the variation of nitrogen oxide emission with angular speed of engine for Jatropha oil blends with Diesel in the test engine. Diesel has higher NOx emission compared to all other blends especially at higher engine speeds. The reduction in both NO and NO_X is a clear advantage with use of Jatropha diesel blends.

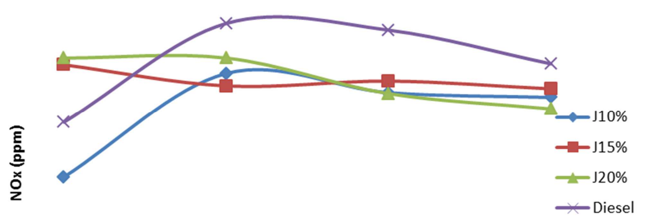

Figure 4. NO_X emission.

4.3.2. Emissions of Engine Running Under Load

Table 7 shows the variation of Carbon monoxide emissions with the torque for Jatropha oil blends with Diesel in the test engine. The amount of CO is higher than diesel at low loading due to incomplete combustion resulted from lower cylinder temperature but CO at higher load less than diesel.

Table 8 shows the variation of nitrogen monoxide emission with torque for Jatropha oil blends with diesel in the test engine. Noted here the NO emission lower than those without load. Generally the NO outcomes slightly increased with an increase of the content of Jatropha oil in the blend. The remote control unit of flue gas analyzer gave no results for diesel fuel.

Table 7. The Variation of Carbon Monoxide Emission versus Torque.

Engine speed	**1600 rpm**		**2200 rpm**	
Type of Fuel	**Engine Torque (N.m)**	**CO (ppm)**	**Engine Torque (N.m)**	**CO (ppm)**
Diesel	90	736	110	3749
J10%	92	2966	99	3195
J15%	92	2591	100	3554
J20%	95	3222	102	3518

Table 8. The Variation of Nitrogen Monoxide Emission versus Torque.

Engine speed	**1600**		**2200**	
Type of Fuel	**Engine Torque (N.m)**	**NO (ppm)**	**Engine Torque (N.m)**	**NO (ppm)**
J10%	92	101	99	110
J15%	92	119	100	113
J20%	95	119	102	127

Most previous studies that tested fuel blend Jatropha oil and diesel did not mention sulfur dioxide as one of the combustion outcomes. Table 9 shows the variation of the sulfur dioxide emission with brake torque of engine. Noted here the amount of SO_2 is higher than diesel at low loading due to incomplete combustion resulted from lower cylinder temperature but SO_2 at higher load less than diesel.

Table 9. The Variation of Sulfur Dioxide Emission versus Torque.

Engine speed	**1600 rpm**		**2200 rpm**	
Type of Fuel	**Engine Torque (N.m)**	**SO_2 (ppm)**	**Engine Torque (N.m)**	**SO_2 (ppm)**
Diesel	90	126	110	966
J10%	92	377	99	379
J15%	92	413	100	484
J20%	95	453	102	386

5. Conclusion

Fuel properties of tested Jatropha-diesel blends (J10, J15 and J20) such as density, viscosity, flash point, cloud point and calorific value were fully determined. It was observed that there is an increase in the density, viscosity, flash point and cloud point of fuel blends with an increase in content of Jatropha oil. On the contrary, the calorific value of fuel blends slightly decreased with an increase of Jatropha oil in the blend.

The engine performance and emission of Jatropha-diesel blends (J10, J15 and J20) was successfully tested on a 4-stroke, 4-cylinder and ID diesel engine. The brake fuel consumption slightly increased with an increase in Jatropha oil in the blend. The brake thermal efficiency decreased and brake power slightly increased with the increase in the content of Jatropha oil. As for the exhaust emissions (CO, NO, NO_x SO_2), there was a decrease with an increase of Jatropha oil in the blend

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