Effect of Blending Jetropha Oil & Kerosene with Diesel Fuel on the Performance of DI Diesel Engine

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Abstract**—** *Practical study was conducted to measure the effect of blending jetropha oil and kerosene with diesel fuel on the work characteristics and performance of a single cylinder 4-stroke water cooled direct injection diesel engine running at fixed speed with various torques. Four types of blend 10% and 20% of kerosene and Jetropha oil blending by volume with diesel fuel were named K10, K20, B10 and B20 respectively, and 100% diesel was considered as a datum line and named Diesel. The treatments include engine speed that was running at constant speed 1600 rpm, with three levels of torque 2, 6 and 10 Nm and five types of fuels 100% Diesel, K10 K20, B10 and B20. Achievement parameters that were studied involve brake specific fuel consumption, brake thermal efficiency and exhaust temperature. Results showed that the bsfc has been reduced by 13.8%, 19.8%, 17.0% and 20.1% when engine fueled with K10, K20, B10 and B20 respectively at low load compared with pure diesel. Exhaust gas temperature, BTE, have been increased when engine fueled with K10, K20, and decreased when engine fuel with B10, B20 instead of diesel fuel(D).These results indicted the possibility of using blending kerosene and Jetropha oil (by 10% and 20% by volume) with diesel fuel without any modification in the engine. That means no modifications required in diesel engine while using up to 20% blending with diesel fuel.*

Keywords— Jetropha oil ; brakes specific fuel consumption (bsfc); exhaust temperature ; brake thermal efficiency (BTE)

I. Introduction

The diesel engine known as a compression-ignition or CI engine is an internal combustion engine in which ignition of the fuel that has been injected into the combustion chamber is caused by the high temperature which a gas achieves (i.e. the air) when greatly compressed. Diesel engines work by compressing only the air. This increases the air temperature inside the cylinder to such a high degree that it ignites atomized diesel fuel that is injected into the combustion chamber.

Internal combustion engines are seen every day in automobiles, trucks, and buses. Diesel engines are widely used worldwide for transportation, decentralized power generation, agricultural applications and industrial sectors because of their high fuel conversion efficiency, rough use and relatively easy operation [1]. However, there exist two major challenges to keep diesel engine as one of the most popular power providers. One is related to fossil fuel the ability to sustain: the crude oil resource on earth is limited stock; this fact is suggesting the researchers for suitable alternative fuels. The other challenge is related with environmental concern. So far, compression ignition engines have adopted many technical breakthroughs to meet the requirements of more and more severe emission regulation . [2].

Kerosene and Jetropha oil are fuel with lower cetane number than 100% diesel fuel, thus it should give a longer ignition delay. This makes it possible for lower emissions since the longer ignition delay means longer time for the fuel to mix with the in-cylinder gas prior to combustion time. [3]. In general, diesel fuel is sometimes referred to as kerosene. The semi-solid of diesel fuel in cold climates is a commonly known observable fact and diesel fuel suppliers, as well as customers and diesel engine designers, have learned over time to manage the cold flow problems associated with diesel fuel in the winter season. [4].

Distinct studies [5-8] have been done by using different vegetable oil blends with kerosene to improve the performance of a small type high speed diesel engine under high load condition only. They worked with a single cylinder direct injection, 4-stroke air cooled diesel engine applying four blends (20%, 40%, 60%, 80% by volume) of soybean oil with kerosene as well as rapeseed oil with kerosene and compared the results with that of pure diesel fuel. They also studied the spray distribution of each blend in atmosphere used four whole nozzle injector. The result shows that a blend of 20% vegetable oil with 80% kerosene by volume fairly improves performance of the test engine under high load. In Nihon University, Japan, Narayan C.M.,[9], have tested a single cylinder , water cooled diesel engine running with blends of a heavy fuel and low grade oil kerosene for comparison of performance to diesel. The results showed that a mixture of 60% fuel oil and 40% kerosene (by volume) improved thermal efficiency clearly in case of heavy loading for high pressure injection. In reference [10] blended in his research kerosene with diesel fuel by 20;80,30:70,40:60,50:50,60:40,70:30 and 80:20 kerosene blends by volume and mentioned that as the load increases the bsfc increase and also mentioned that blending kerosene with diesel fuel contributes slightly increased in engine emissions. In reference paper the researcher[11] achieved in his experimental research that the combustion quality of kerosene and its blends with diesel are to a large extent, affected by the calorific values of the fuels, ignition ability, and fuel mixture, reactant concentrations and their specific heat capacities

Now, Day to day the diesel fuel price in India, increasing gradually, and vegetable and non edible oil easily available Indian market, therefore It is needed to choose alternative fuel of Diesel fuel. According to that it is necessary to make experiments in which specific ratio diesel fuel can be mixed with kerosene and Jetropha oil on condition that this mixture doesn’t affect the performance and emissions of diesel engine, thus, kerosene and jetropha oil can be used in India and decrease the import of diesel fuel too.

II. MATERIALS AND METHODS

A. *Fuel Used*

Pure 100% diesel fuel (named D) was purchased from local petrol pump and used as datum line fuel. Four blends of diesel – kerosene and jetropha oil (with 10% and 20% kerosene and jetropha oil blending by volume) were named K10, K20, B10 and B20 respectively, were used in this experiment. The properties of the tested fuels are shown in Table 1.

DATA	D	K10	K20	B10	B20
SP. Gravity @ 15.6˚C	0.834	0.831	0.827	0.867	0.875
API. Gr. @ 15.6˚C	38.1	38.7	39.5	39.8	40.1
Flash point ˚C	77.0	70.9	65.0	89.0	89.0
Colour (ASTM)	0.50	0.50	0.50	0.48	0.46
Pour Point ˚C	-15	-18	-18	-5	-5
Vis Cst @ 40 ˚C	3.00	2.80	2.56	3.00	3.02
Carbon Res. Wt %	0.10	0.80	0.50	0.25	0.30
Sulfur. Wt %	1.20	1.09	0.98	0.95	0.96
Density @ 15.6˚C kg/m3	834	831	827	862	865
Cetane No.	56	57	58	52	48
Calorific Value KJ/Kg	45786	45828	45886	36540	36420

Table – 1: Prperties of fuels used

B. *Test Engine*

The measurement was conducted in a single cylinder four stroke, water cooled Direct Injection diesel engine. The specifications of the engine have been shown in Table 2.

ITEM	SPECIFICATION
Engine Manufacture	FH-785, FM
Fuel Type	Diesel
No. of Cylinders	1
Max. Torque Nm@RPM	33 Nm @1400-1600 rpm
Displacement	625 cm3
Bore	85 mm
Stroke	110 mm
Compression Ratio	18:1
Rated RPM	2600 RPM

Table – 2: Specifications of testing engine.

The test engine set up and accessories are shown in Figure:1

The engine test accessories include:

C. *Engine Cycle Analyzer (ECA 100)*

Fully Computerized specially modified with cylinder head pressure transducer and crank angle encoder.

D. *Data Acquisition System (DAS) & Lab view Software*

The DAS apparatus is a two-part product (hardware and software) that allows the user to reduce errors, save experiment time, record the test results in a suitable compute and automatically calculate important values.

E. *Instrumentation Unit.*

The instrumentation unit is designed to contain the instruments necessary for measuring the engine performance measurement, which include fuel consumption, torque in Nm, and exhaust gas temperature on display.

Fig. 1: Photo of Engine test rig.

The engine was linked horizontally with a hydraulic dynamometer which is directly connected with computer. The fuel flows into the bottom of a pipette, graduated in ml. Fuel consumption is determined by measuring the time (t) taken for the engine to consume a given volume of fuel. Exhaust gas temperature is measured by a thermocouple, while the air consumption is measured by orifice chamber method.

III. TEST PROCEDURE

First of all system is bleeder and refilling with 100% diesel fuel before preparing test requires, removing any air bubbles that may be collected in the fuel system, the engine run without load for 30 minutes for warming up and system clean up intention. The speed of the engine was increased slowly by the control level of the fuel at the same load until the engine speed becomes stable, which is determined from the stability of the exhaust temperature. speed of engine was fixed at 1600 rpm, and the torque was increased to 2 Nm gradually by increasing the flow of water in dynamometer which was controlled by a valve and tab and let the engine works for 5 minutes at that fixed speed and load, then the tap on the fuel line was closed to bypass the fuel tank from the engine to measure the fuel to be consumed from the pipette. The fuel consumption was found by measuring the time taken by the engine to consume a given volume of fuel, during that procedure, results were recorded which include air consumption from manometer of the Intake air measurement unit, exhaust temperature from meter of exhaust temperature in instrumentation unit through thermocouple.

In the second step the torque changed to 6 Nm and the previous steps were repeated and so that for the rest torque 10 N.m, in the end/ at last, the temperature and pressure of the laboratory were recorded. Then, other types of fuel were used by applying the same steps above. When changing the fuel to another type K10, K20, B10 and B20, draining and flushing the system must be done. Every test was repeated three times to be more accurate and the average value was taken. Brake power, brake specific fuel consumption and brake thermal efficiency was calculating using the collected test data.

IV. RESULTS AND DISCUSSION

The brake specific fuel consumption is the ratio of mass fuel consumption to the brake power and it shows how good the engine performance is [12]. Fig. 2 shows the variation of bsfc with loads for the diesel engine test fueled with 100% diesel, K10, K20, B10 and B20. It is shown from the graph that as the load increases the bsfc goes down for all fuels tested, at the same time it can be showed that bsfc decreases with increase kerosene addition and slightly decreases with jetropha oil addition. The higher bsfc (500.54 g/kW.h) registered with pure diesel fuel at low load while K10, K20,B10 and B20 blend fuels registered 431.20 g/kW.h, 401.61 g/kW.h, 415.15 g/kW.h and 399.50 g/kW.h respectively at the same load and speed, the reason may be due to the higher density and lower heating value of 100% diesel fuel cause a reduction in brake power and consequently increasing the bsfc. The figure also showed that there were no major differences in bsfc for all types of fuel at full load condition.

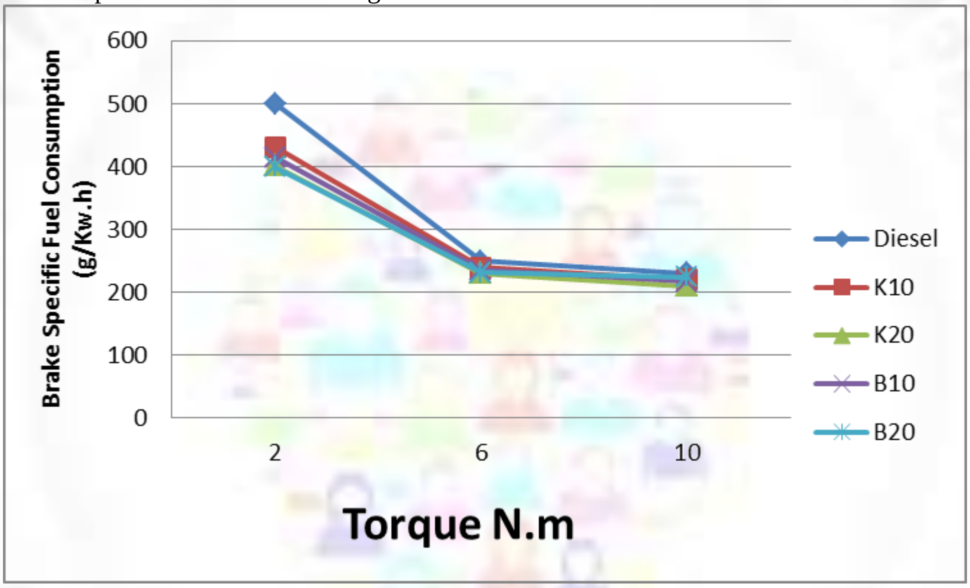

Fig. 2: Variation in bsfc with engine torque for diesel and Four blends kerosene diesel fuel and Jetropha oil

Thermal efficiency can be expressed as the ratio of the network output to the energy required to produce that work output. If the work output is brake power, then the thermal efficiency is called brake thermal efficiency (BTE) [13].

Fig. 3 shows the effect of fuel type on BTE at different loads with engine run at 1600 rpm. It has been seen from the graph that the BTE increased as load increase for all types of fuel tested. Brake thermal efficiency is always found to be higher with increasing the kerosene blends as compared with 100% diesel fuel, this is because of the fuel properties such as lower viscosity, density, and higher calorific value of blends K10 and K20(kerosene have a higher calorific value). Also, Brake thermal efficiency is always found to be decreasing the jetropha oil blends as compared with 100% diesel fuel, this is because of the fuel properties such higher viscosity, density, and lowers calorific value of blends B10 and B20. The higher BTE value was 33.89% observed by blend fuel K20 at full load while diesel fuel observed the 32.75% and B20 observed 31.82% BTE at the same load and speed. The lowest BTE value was 14.75% observed by using B20 fuel at low load (torque 2 Nm) and engine speed 1600 rpm ,while when using blends fuel K10, K20 and B10 the BTE values were 17.62% , 18.80% and 15.03% respectively at the same load and speed.

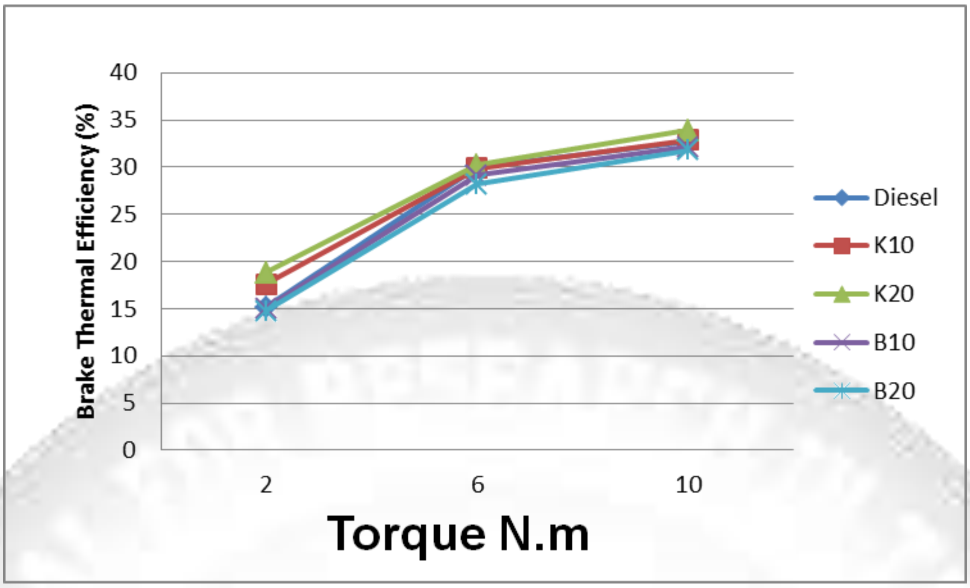

Fig. 3: Variation in BTE with engine torque for diesel and Four blends kerosene diesel fuel and Jetropha oil.

The result or outcomes of fuel types on the exhaust temperature at different loads is presented in Fig. 4. As shown in the figure, exhaust gas temperature gradually increases as an engine load increases for all fuel tested. On the other side it is found that exhaust gas temperature increases with kerosene addition to diesel fuel due to the higher calorific value of kerosene – diesel blend over 100% diesel fuel that caused a high pressure inside the cylinder during combustion of the fuel is equivalent to high escape velocity and longer spray length, provide high atomize of the fuel and complete combustion take place which reduces the delay periods, and consequently increase the exhaust gas temperature. The exhaust gas temperature decreases with Jetropha oil addition to diesel fuel due to high viscosity of fuel and more delay periods. The highest exhaust temperature was 316 °C recorded by blend fuel K20 at full load, while using diesel fuel recorded 241 °C at the same load. The lowest exhaust gas temperature 101 °C recorded by B20 fuel at low load.

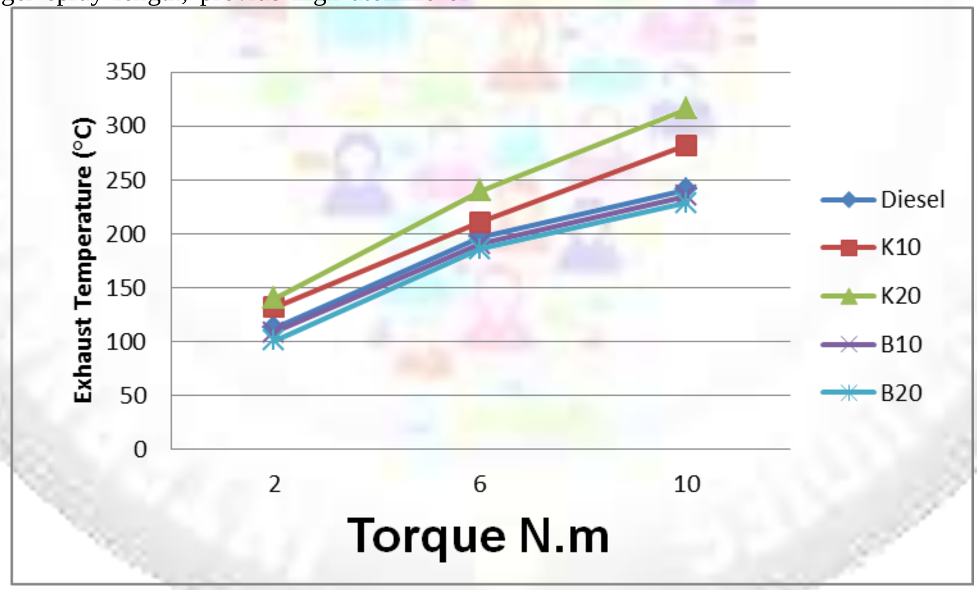

Fig. 4: Variation in exhaust temperature with engine torque for diesel and Four blends kerosene diesel fuel and Jetropha oil.

V. Conclusion

1) Brake thermal efficiency has been slightly improved with K10 and K20 blends as compared with 100% diesel fuel, and Brake thermal efficiency has been slightly decreased with B10 and B20 blends as compared with 100% diesel fuel.
2) Exhaust gas temperature has been increased when engine fueled with K10 and K20 as compared with 100% diesel fuel, because of kerosene fuel have higher calorific value and Exhaust gas temperature have been decreased when engine fueled with B10 and B20 as compared with 100% diesel fuel, due to bio diesel have lower calorific value.
3) The bsfc has been reduced by 13.8% , 19.8%, 17.0% and 20.1% when engine fueled with K10, K20, B10 and B20 respectively at low load as compared with 100% diesel.

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