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Influence of Various Blends of Karanja oil with Pure Diesel on Performance, Emission and Combustion Characteristics of Diesel Engine: An Experimental Investigation

Brahma Nand Agrawal, Shailendra Sinha

Abstract*: An experimental investigation has been carried out to analyze the performance parameters, emissions and combustion characteristics of a diesel engine fuelled with blends of karanja oil (10, 20, 30, 40, and 50%) with diesel at different load conditions. The blend K50D50 shows maximum indicated power of about 50W than that of pure diesel at 72% load to full load. The blend K50D50 shows 4% greater mechanical efficiency than that of pure diesel at 50% of the load. The blend K50D50 has been showing greater brake thermal efficiency than pure diesel from 47% to 76% of the load. At no load condition, the specific fuel consumption of blend K50D50 is less than that of pure diesel of about 0.5 kg/kWh. The blend K50D50 emits lowest HC emission among all blends and pure diesel irrespective of various loads. However, CO emissions are still comparable to pure diesel. The blend K50D50 emits the lowest quantity of smoke among all blends and pure diesel for an average load. The blend K50D50 shows higher peak cylinder pressure is about 2.21bar than that of pure diesel at full load. In the blended fuel operation, the mean gas temperature, the rate of pressure rise and net heat release rate are higher by about 324 – 37 7^{0}C, 1.31 – 1.57 bar/ ^{0}CA and 9 – 13 J/^{0}CA than those of pure diesel respectively. The result reveals that K50D50 is the optimum blend among all blend without any modification of the engine.

Index Terms*: Combustion characteristics, Diesel engine, Emission, Karanja oil.

I. INTRODUCTION

Vegetable oils and products synthesized from natural raw materials have a strong comeback in recent decades. Several kinds of literature are available, they have been dealing with vegetable oils as bio-fuel. In this context, the control of NO_x emissions in biodiesel-fueled compression ignition engine blended rice bran oil with diesel. This reduces exhaust emissions and improves thermal efficiency [1]. The effect of blending on the combustion characteristics and exhaust emission were measured. The results revealed that by using of biodiesel, lower smoke produced. Over the entire load conditions, all blends of SME were produced lower UHC concentration compared to that of diesel [2].

A new common rail direct injection (CRDI) system developed. Authors have successfully reduced the engine out emissions except NO_x using newly developed CRDI system [3]. The combustion parameters of the diesel engine have been investigated by using biogas, higher cylinder pressure achieved [4]. An experimental investigation did on ignition delay by using blends of n-pentane and diethyl ether with pure diesel. The results noticed that the diethyl ether reduces the ignition delay of diesel fuel effectively at lower temperatures [5]. Many characteristics for performance parameters exhaust emission and combustion parameters should be needed attention. Therefore in this study, major characteristics were systematically investigated when fuelled with 10% Karanja oil and 90% diesel (K10D90), 20% Karanja oil and 80% diesel (K20D80), 30% Karanja oil and 70% diesel (K30D70), 40% Karanja oil and 60% diesel (K40D60), and 50% Karanja oil and 50% diesel (K50D50) on volume bases at compression ratio 15. The aim of this study is to find an optimum blend.

II. EXPERIMENTAL APPARATUS AND PROCEDURE

Direct injection and variable compression ratio engine, single cylinder, four strokes, water cooled, was utilized for the test. The necessary details of the engine are given in Table 1 and the schematic diagram of the engine is shown in Figure 1.The engine connected to a computer. Engine performance analysis software which named as Engine-soft-LV was used. Different loads were applied to the engine coupled with an eddy current type dynamometer. A smoke meter, which model AVL 437C was used for measurement smoke in the exhaust of the engine. For measure, the exhaust emissions such as smoke, CO, and HC, Gas analyzer AVLDIGAS 444 was used.

Table 1: Engine specification

Engine specification	
Type	DI, naturally aspirated, four stroke, water cooled
Rated power	3.5 kW @ 1500rpm

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Compression ratio	15
CR range	13-18
Cylinder number	1
Bore and stroke	87.5 mm x 110 mm
Total cylinder volume	661cm^3
Injector opening pressure	210 bar
Start of IT	23^0 CA BTDC

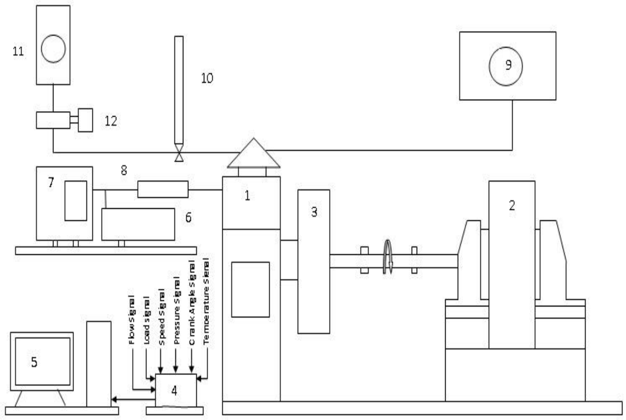

Figure 1 Experimental set-up line diagram. 1 – Variable compression ratio engine, 2 – eddy current dynamometer, 3 – flywheel, 4 – data acquisition device, 5 – computer, 6 – smoke meter, 7 – exhaust gas analyzer, 8 – calorimeter, 9 – air box, 10 – burette, 11 – fuel tank, 12 – control valve

III. RESULTS AND DISCUSSION

A. *Performance parameters*

This section deals with the optimum result obtained from the experiment. It was observed that the different results have been obtained at different loads and different blends. Analyze the performance parameters of karanja oil blended with diesel. While operating on different composition, so many behaviors have been observed for different performance parameters, which are discussed below.

3.1.1. *Indicated power*

It is observed from Figure 2, up to 72% of load pure diesel gives greater indicated power than all blends of karanja oil, however, at full load higher concentration of karanja oil gives better results. From 72% load to full load the blend K50D50 gives maximum indicated power by amount 50W to pure diesel.

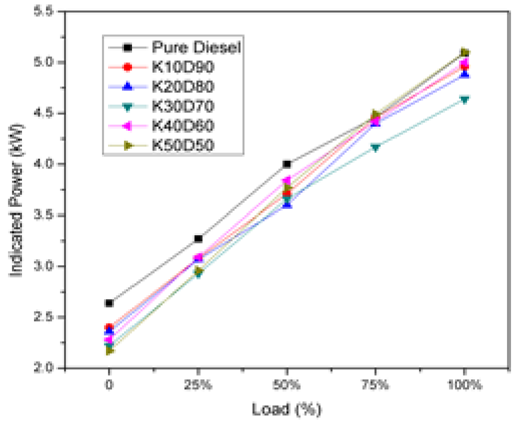

Figure 2. Variation of IP with load

3.1.2. *Indicated mean effective pressure*

Figure 3 illustrated that the lower concentration of karanja oil gives lower indicated mean effective pressure at lower load. However, increasing the load all blends of karanja oil gives quite similar results and a higher concentration of karanja oil give better results at higher load. K40D60 blend has the quite similar value of the indicated mean effective pressure (IMEP) at all different load conditions from 0 to 100%. The blend K50D50 gives same results to pure diesel from 75% load to full load.

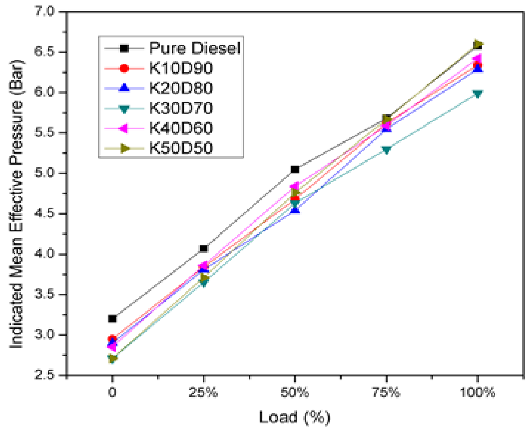

Figure 3.Variation of IMEP with load

3.1.3 *Mechanical efficiency*

From the experiment result it is observed that from Figure 4, K20D80 and K30D70 blends give greater mechanical efficiency (ME) than all other blends and pure diesel at higher load condition. However, K40D60 and K50D50 blends give greater mechanical efficiency irrespective of all loads than that of pure diesel. The blend K50D50 gives 4% greater efficiency than that of pure diesel at 50% of the load.

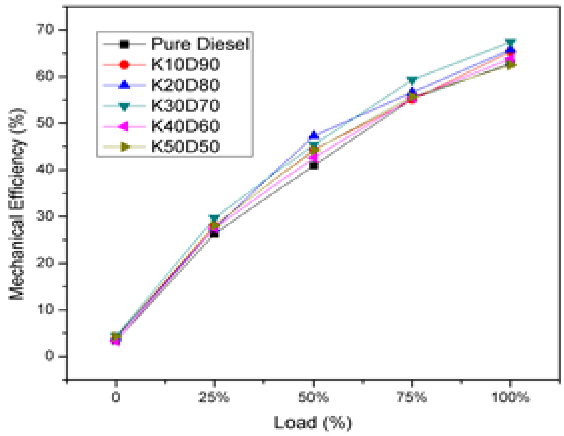

Figure 4. Variation of ME with load

3.1.4. *Brake thermal efficiency*

From Figure 5, it is clear that K20D80 and K30D70 have more brake thermal efficiency than other blends and pure diesel irrespective of load. However, from 47% to 76% of load, K50D50 has greater brake thermal efficiency (BTE) than pure diesel and K40D60 blend.

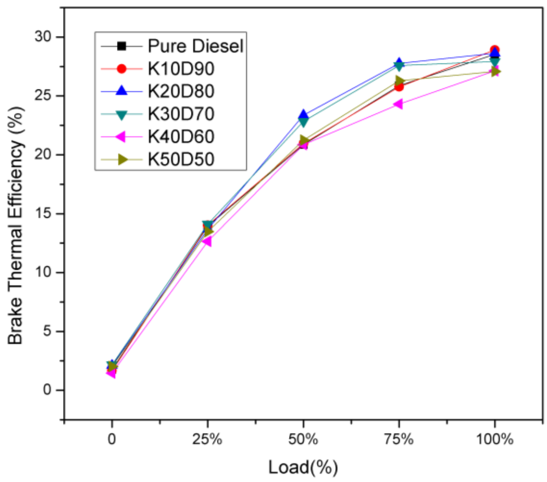

Figure 5. Variation of BTE with load

3.1.5. *Specific fuel consumption*

An indication of efficient combustion of fuel is specific fuel consumption (SFC). Figure 6 shows the variation of SFC while using the Karanja oil blends and pure diesel with respect to different loads. Specific fuel consumption of all blends except K40D60 is less than pure diesel at all load condition. At no load condition, SFC of blend K50D50 is less than that of pure diesel by the amount of 0.5 kg/kWh. SFC of Karanja oil blends and pure diesel decreases with increases in load due to better combustion [6].

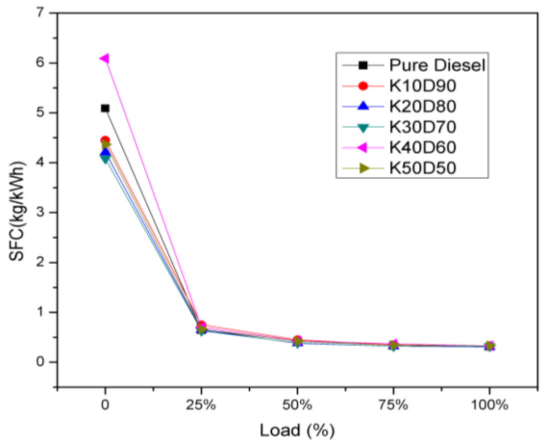

Figure 6. Variation of SFC with load

B. *Emissions*

3.2.1. *CO emission*

Due to incomplete combustion, there is a loss of energy of fuel in the form of CO emission. It has been widely accepted that combustion chamber geometry influenced CO emission, advance in ignition timing, air-fuel ratio, load and speed, atomization rate. Figure 7 illustrated that by the increasing load, CO emission decreases. The blends K20D80 emit less quantity of CO emission than that of pure diesel irrespective of loads. CO emission is nearly same at full load by using the blend K50D50 and pure diesel.

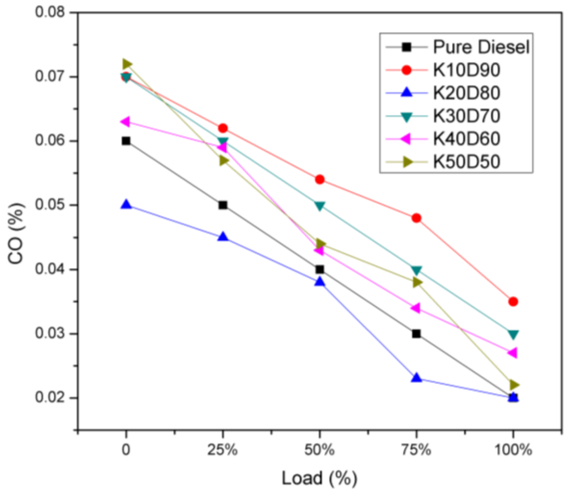

Figure 7. CO emissions Vs load

3.2.2. *HC emission*

The fact illustrated in Figure 8 that the blend K50D50 emits lowest HC emission among all blends and pure diesel irrespective of loads. The blend K20D80 emits low HC emission than that of pure diesel and other blends except K50D50. By using the bio-fuels, a substantial reduction in carbon monoxide (CO) and hydrocarbon (HC) emissions has been noticed when compared to pure diesel [7].

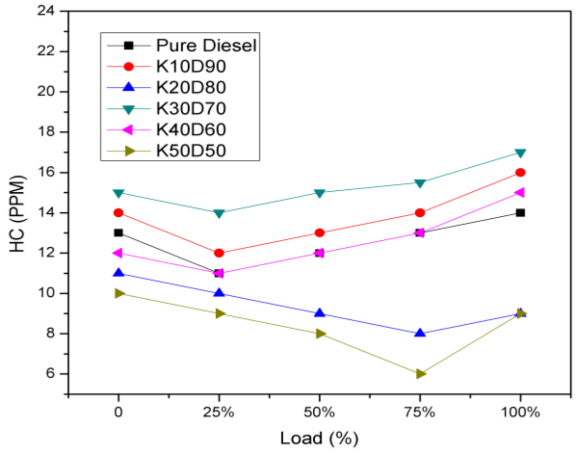

Figure 8. Variation of HC emissions with load

3.2.3. *Smoke*

In a diesel engine, smoke is mainly produced in rich fuel region and in the diffusive combustion phase. Non-edible oil, being the oxygenated fuel, reduces over the rich region, it results in an improvement in diffusive combustion. Figure 9 illustrated that as increasing load, smoke increases at all five and pure diesel. From 33% to 92% of the load in which engine run mostly, the blend K50D50 emits the lowest quantity of smoke among all blends and pure diesel also.

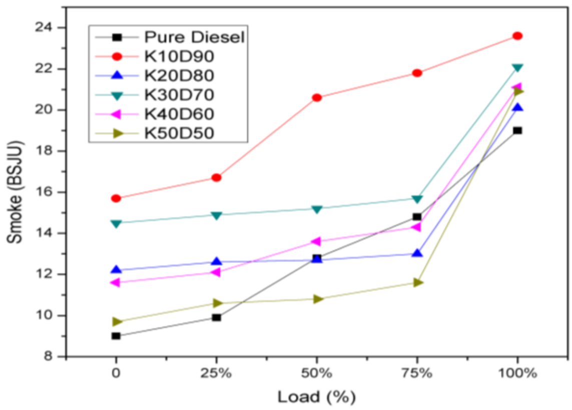

Figure 9. Variation of Smoke emissions with load

C. *Combustion characteristics*

In this section, analyze the combustion characteristics of karanja oil blended with diesel at different load condition and constant speed. Combustion characteristics influence the performance parameter and emissions of the engine. These combustion characteristics of Karanja oil blends compared with pure diesel and discussed below.

3.3.1 *Cylinder pressure with crank angle history*

The cylinder pressure (CP) is a description of the fuels ability to mix with the air completely and then burn. It depends upon the fueled burned fraction during the premixed combustion phase. The premix is controlled by the ignition delay, air-fuel mixture and spray envelop. Hence, the viscosity and velocity of the diesel blends play an important role to increase the atomization rate and to improve the formation of the air-fuel mixture. Generally, the cylinder peak pressure of biodiesel and its blends is lower than that of neat diesel fuel.

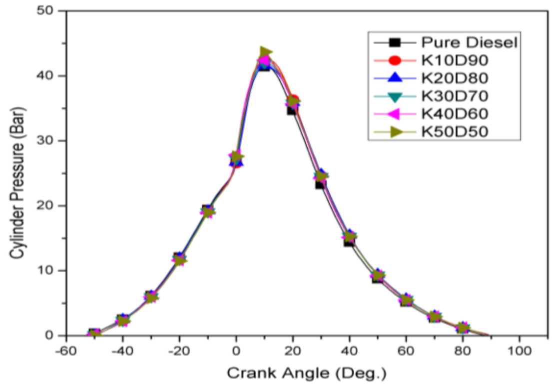

Figure 10. CP Vs CA

The variation in cylinder pressure with a crank angle (CA) of different Karanja blends with pure diesel is shown in Figure 10. Blend K50D50 gives maximum peak cylinder pressure when compared to other blends.

For pure diesel, the peak cylinder pressure is about 41.48 bar, which occurs at 9 ^{0}CA aTDC, whereas for blends the peak pressures of 42.53 bar, 41.63 bar, 42.03 bar, 42.43 bar, and 43.69 bar are noticed at about 11 ^{0}CA aTDC, 10 ^{0}CA aTDC, 10 ^{0}CA aTDC, 10 ^{0}CA aTDC, 10 ^{0}CA aTDC for K10D90, K20D80, K30D70, K40D60 AND K50D50 respectively at full load.

3.3.2 *Mass fraction burned*

Mass fraction burned is known as the content of trapped charge of the cumulative heat release values which is divided by the total energy. At a specific crank angle, the mass fraction burned can be expressed by the energy conversion. It can be shown from result data that the value of MFB 15% to 85% for blend K30D70 is maximum compared to all blends and pure diesel as illustrated in Figure 11.

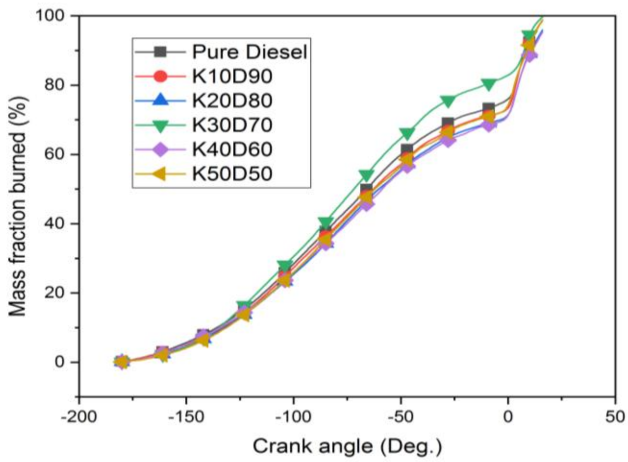

Figure 11. Variation of mass fraction burned with crank angle

3.3.3 *Cumulative heat release*

The aggregate sum of instantaneous heat release rates is called the cumulative heat release (CHR) which shown in Figure 12. The trend of the curve has an S shape. At the beginning, the rate of heat release and reaching a peak value rapidly then again slow down.

The value of cumulative heat release is quickly exceeded by using blends K40D60 and K20D80. The cumulative and instantaneous heat release rates for diesel-biodiesel-DEE blends start earlier. However, this rate exceeds quickly by diesel fuel curves for all loading conditions [8].

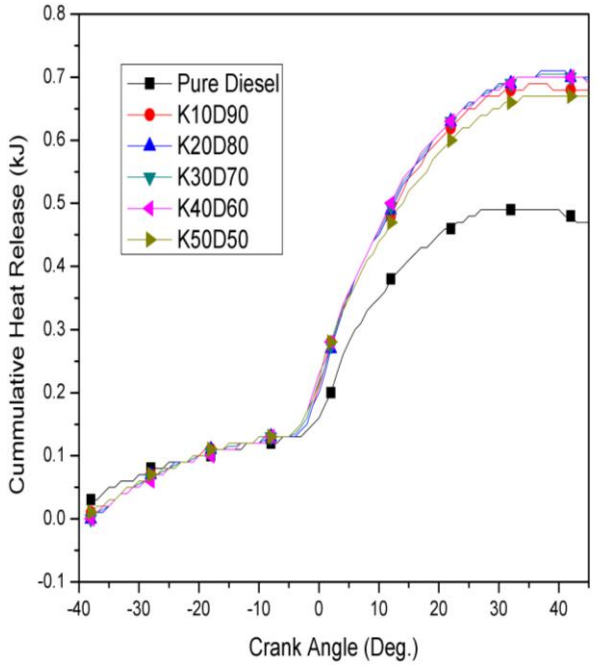

Figure 12. Variation of CHR with crank angle

3.3.4 *Mean gas temperature*

Figure 13 shows the variation of mean gas temperature (MGT) with crank angle. From the figure, it can be observed that the value of highest mean gas temperature are 747.64 ^{0}C, 1072.39 ^{0}C , 1099.28 ^{0}C, 1112.15 ^{0}C, 1125.56 ^{0}C and 1072.35 ^{0}C at pure diesel, K10D90, K20D80, K30D70, K40D60 and K50D50 respectively. It is cleared that all blends have a maximum mean gas temperature than that of pure diesel. As the blending ratio increases its ignition delay decreases due to the high cetane no. of biodiesel fuel, therefore, mean gas temperature increases at higher blends.

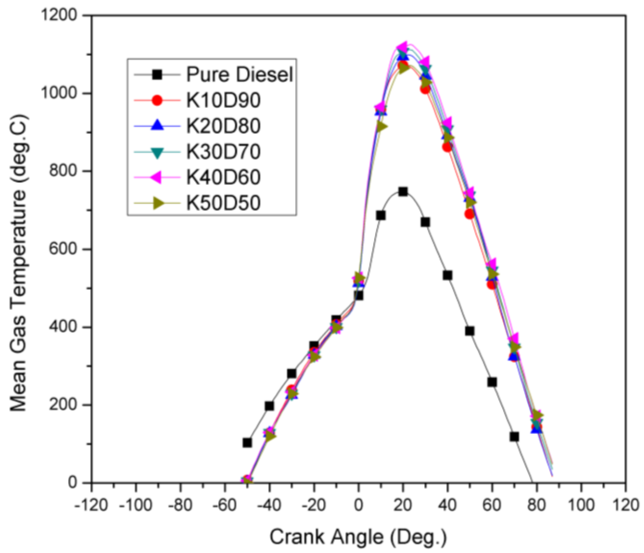

Figure 13. Variation of MGT with **crank angle**

IV. CONCLUSION

The aim of this study to investigate the Karanja oil blended with diesel were prepared and tested on a diesel engine. The conclusions are as follows;

- The karanja oil has the potential to substitute diesel up to 50% by volume.
- In this study, the blend K50D50 gives the optimum result.
- The blend K50D50 shows maximum indicated power of about 50W than that of pure diesel at 72% load to full load.
- The blend K50D50 shows 4% greater mechanical efficiency than that of pure diesel at 50% of the load.
- The blend K50D50 has been showing greater brake thermal efficiency than pure diesel from 47% to 76% of the load.
- At no load condition, SFC of blend K50D50 is less than that of pure diesel of about 0.5 kg/kWh.
- The blend K50D50 emits lowest HC emission among all blends and pure diesel irrespective of loads. However, CO emissions are still comparable to pure diesel.
- From 33% to 92% of load in which engine run mostly, the blend K50D50 emit the lowest quantity of smoke among all blends and pure diesel.
- At full load, the blend K50D50 shows higher peak cylinder pressure is about 2.21bar than that of pure diesel.
- **T**he mean gas temperature **is** higher by about 324 – 377 ^{0}C than those of pure diesel respectively.

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