Experimental investigation of CI engine performance and emissions characteristics of CI engine fuelled with different bio fuel –diesel blended fuel

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Abstract: Bio fuel's versatility to utilize in compression ignition engine by reducing the viscosity of the fuel. This paper deals performance and emission characteristics of four stroke single cylinder diesel engine coupled with eddy current dynamometer. The fuel was prepared in the combinations of B10 CH(10% camphor oil +90% diesel), B20 CH (20% camphor oil +80% diesel), B10 E(10% eucalyptus oil +90% diesel), B20 E (20% eucalyptus oil +80% diesel), B10 LG (10% lemon grass oil + 90% diesel), B20 LG(20% lemon grass oil + 80% diesel), B10 CSO(10% cotton seed oil +90% diesel), B20 CSO( 20% cotton seed oil + 80% diesel). The experiment was conducted by the varying the load (20%, 40%, 60% and 80%) at constant speed 1500rpm. The result shows that BTE is higher in B20E fuel 7.7% and lower in B10LG fuel 2%. BSFC higher in B20CH and lower in B20E. CO emissions are higher in B10CSO, HC emission are higher in B20CSO, B20LG higher in NOx emissions and lower in B20CH fuel CO2 emission is higher in B20CSO and lower in CO2 emissions. These are results obtained from the performance of engines. B20E produces better performance for the IC engines.

Keywords: CI Engine, Biofuel, camphor oil, Eucalyptus oil, lemon grass oil, cotton seed oil

1. Introduction:

Many developing countries searching for eco friendly and most economical fuel. Many bio fuels have tried as fuel for the compression ignition engine. Major drawback of using the bio fuel in Diesel engine was its higher viscosity, lower cetane number and calorific value and poor volatility. Viscosity of the fuel leads to poor atomization causes the incomplete combustions. High viscosity of the fuel leads to cloaking of the filters and fuel injectors and also increases the pumping power. Higher viscosity of fuel leads to longer ignition delay leads to rise in peak pressure very close to TDC and creates Knocking. Most of the plant oil like cotton seed oil, jatropha oil, pungamia oil, neem oil, palm oil, sunflower oil, soybean oil, canola oil, corn oil, jojoba oil, mahua oil, Rubber seed oil hazelnut oil etc has higher viscosity than diesel [1-5]. cetane number is the property of the fuel which define the ignition quality of the fuel. Fuel which has higher cetane number supports for good combustion than the lower cetane number fuel. Cetane number of the biofuel like cotton seed oil, neem oil. jatropha oil,
karanja oil, mahua oil, jojopha oil. Density is property of the fuel. Density of the fuel influence on the fuel consumption and pollutant emissions rate. Higher density fuel has higher mass flow rate and increase the specific fuel consumption. Main advantage of the biofuel was its higher oxygen content which supports for good combustion characteristics. Blending of the bio fuel with diesel fuel reduces the viscosity of fuel blend and reduces the problems associated with viscosity.[6] Senthil raja invested that cotton seed oil with methyl ester will reduces the NOx, CO2 emissions at any condition of loads.[7] Mathan Raj found that CSO will increases the BTE but decreases the SFC and EGT, it increases HC emissions.[8] Srinivas found that at the higher injection pressure of 220 bar of eucalyptus blended oil overall emissions are lowered and increases in compression ratio.[9] Scholar found that B15CH85 will increases the BTE 34% at full load conditions and it increases NOx emissions.[10] Ashok found that at the lemon peel oil blend will reduces the CO, HC and Smoke emissions.

2. Methods and methodology:

2.1 Experimental Setup:

Performance, emission and combustion test was conducted on the computerised single cylinder diesel engine coupled with eddy current dynamometer whose layout was shown in the figure 1 and its specification was given in the Table 1 by varying the load at constant speed 1500rpm. Engine was allowed to run for diesel fuel for half an hour to attain the steady state. Air flow rate was measured with the help of air surge tank coupled with orifice plate and u tube manometer and fuel volume flow rate with the help of Burette with stop watch. Engine cooling water flow rate was measured with help of rota meter. Exhaust gas temperature was measured with thermocouple. Emission was measured with using AVL gas digas analyser whose details was given in the Table 4. The fuel property was listed in the Table 1 and Table 2.

| Description          | Specification                     |
|----------------------|-----------------------------------|
| Make                 | Kirloskar                         |
| Type                 | TV1                               |
| No of cylinder       | Single cylinder                   |
| No of stroke         | Four stroke                       |
| Rated power          | 5.2 kW (7 BHP) at 1500 rpm        |
| Type of Dynamometer  | Type Eddy current                 |
| Type of cooling      | Water cooling                     |
| bore                 | 87.5 mm                           |
| stroke               | 110 mm                            |
| capacity             | 661 CC                            |
2.2. Engine Setup:

1. AVL gas analyzer
2. burette
3. temperature indicator
4. fuel tank
5. air tank
6. u-tube manometer
7. load indicator and speed indicator
8. speed sensor
9. loading sensor
10. cooling water inlet temperature
11. cooling water outlet temperature
12. EGT

Table 2. Properties of Fuels

| Properties                | Diesel | Camphor oil | Eucalyptus oil | Lemon grass oil | Cotton seed oil |
|---------------------------|--------|-------------|----------------|-----------------|-----------------|
| Density (kg/m³)           | 840    | 890         | 913            | 876             | 920             |
| Viscosity at 40°C cST     | 5.6    | 1.9         | 3.2            | 3.6             | 35.2            |
| Cetane Number             | 45     | 5           | 52             | 37              | 38              |
| Higher calorific value    | 44     | 38.2        | 43             | 38.5            | 39              |

Table 3. Properties of Fuels

| Properties                | B10CH | B20CH | B10 E | B20 E | B10L G | B20L G | B10 CSO | B20 CSO |
|---------------------------|-------|-------|-------|-------|--------|--------|---------|---------|
| Density (kg/m³)           | 845   | 850   | 847   | 854   | 843    | 847    | 848     | 856     |
| Viscosity at 40°C cST     | 5.2   | 4.8   | 5.3   | 5.1   | 5.4    | 5.2    | 8.5     | 11.5    |
| Cetane Number             | 41    | 37    | 45    | 46    | 44     | 43     | 44      | 43      |
| Higher calorific value    | 43    | 42    | 43    | 43    | 43     | 43     | 43.5    | 43      |
| MJ/kg                     | 43    | 42    | 43    | 43    | 43     | 43     | 43.5    | 43      |
Table 4. Specifications of measuring instruments

| Instrumentation       | Component | Measuring range | Accuracy  | Resolution |
|-----------------------|-----------|-----------------|-----------|------------|
| AVL gas Digas 444 Analyser | HC (PPM)  | 0-20000         | ± 10PPM   | 1ppm       |
|                       | Co (% by vol) | 0-10% by vol | ±0.5%     | 0.01% vol  |
|                       | Co₂(%by vol)  | 0-20% by vol   | ±0.5%     | 0.1% by Vol|
|                       | O₂ (%by vol)  | 0-22% by vol   | ±0.1%     | 0.01% by vol|
|                       | Nox (ppm)    | 0-5000ppm       | ±50 ppm   | 1PPM       |

3. Results and discussion:

3.1. Engine Performance:

3.1.1 Brake thermal efficiency:

Brake thermal efficiency varies directly with respect to increase in load. BTE of diesel was found higher than all low blended fuel. BTE for diesel was found 5%, 12%, 8%, 11%, 6%, 9%, 10% and 16% higher than B10CH, B20CH, B10E, B20E, B10LG, B20LG, B10CSO and B20 CSO at 20% of loading condition of the engine. BTE for diesel was found 3.6%, 6.5%, 4.6%, 7.7%, 2%, 4%, 4.4% and 3.8% higher than B10CH, B20CH, B10E, B20E, B10LG, B20LG, B10CSO and B20 CSO at 80% of loading condition of the engine. Increasing the blending ratio of the straight oil on volume leads to reduction in BTE. Brake thermal efficiency of blended fuel was very close to diesel when the engine operating at 40% and 60% loading condition for all low blended fuel in volume basics because of the higher oxygen content of blended fuel.

3.1.2 Brake specific fuel consumption:

Variation of brake specific fuel consumption with respect to load was shown in the figure 3. Brake specific fuel consumption for diesel was found lower than all low blended fuel because of the higher calorific value and low density. Increasing the blending ratio of the camphor oil, eucalyptus oil, lemon grass oil and cotton seed oil in the fuel on volume basics leads to increase in the density and higher specific fuel consumption. B10E, B10LG and B10CSO has closer value to diesel when operating at 40 to 60% loading conditions of the engine because of the higher oxygen content of the eucalyptus oil, lemon grass oil and cotton seed oil. Brake specific fuel consumption for diesel was found 4%, 9%, 8%, 9%, 4%, 8%, 5% and 5% lower than B10CH, B20CH, B10E, B20E, B10LG, B20LG, B10CSO and B20 CSO at 80% of loading condition of the engine.
3.2 Emission characteristics:

3.2.1 Carbon mono oxide:

Figure 4 shows the variation of the carbon mono oxide with respect to load. Co emission of B10CSO was found higher than remaining fuel when operating all loading conditions because of the higher viscosity of the fuel. In mean time higher oxygen content of the B20CSO supports the combustion and reduces the Co. At higher loading conditions diesel has found lower than B10CSO but
higher than remaining fuel. This is because of the oxygen content of the remaining fuel supports for the combustion. Maximum Co was found for B10CSO at lower loading condition of the engine.

![Graph](image)

**Figure 4.** Variation carbon mono oxide with respect to load

### 3.2.2. Unburnt Hydrocarbon:

Variation of the un-burnt hydrocarbon with respect to load was shown in the figure 5. All the low blended fuel has lower emission of un burnt hydrocarbon than diesel when the engine operating up to 80% of loading condition of the engine except B20CSO. Increase in the blending ratio of the camphor oil, cotton seed oil and lemon grass oil leads to increase in un burnt hydrocarbon but in case of eucalyptus oil, increase in the blending ratio leads to lower hydrocarbon emission at all loading conditions of the engine. Maximum emission of hydrocarbon was found for the lemon grass blended fuel at 80% loading condition when compared to remaining fuel. B10CSO has lower hydrocarbon emission when compare to remaining fuel but increasing the blending ratio of the cotton seed oil with diesel in volume basis increase the Hydrocarbon emission.

### 3.2.3. Oxides of nitrogen:

Variation of the oxides of nitrogen was shown in the figure 6. Nox emission for the B10CH, B20CH, B10E, B20E, and B10CSO was found lesser than diesel fuel for the all loading conditions of the engine. B20LG was found higher than diesel and remaining low blended fuel for all loading conditions of the engine. B20CSO has the higher Nox emission when compare to remaining fuel operating at 60 to 80% loading conditions of the fuel. This is because of the high oxygen content of the cotton seed oil fuel which supports for the more Nox formation. Nox emission for B20LG was found higher and B10CH as lower in the most of the loading conditions of the engine.
Figure 5. Variation hydrocarbon with respect to load

Figure 6. Variation oxides of oxides of nitrogen with respect to load

3.2.4. Carbon di-oxide:

The variation of carbon di-oxide with respect to load was shown in the figure 7. B10Ch, B20CH, B10E, B20E, B10LG was found lower than diesel when the engine operating at all loading conditions. B10CSO and B20CSO higher carbon di-oxide emission when compare to diesel fuel. This is because of the more oxygen content of cotton seed oil. B10CH has the lower carbon di-oxide emission when compare to diesel, cotton seed oil and lemon grass oil blended fuel. B10CSO and B20CSO have higher carbon di-oxide emission when the engine operating at the 40 to 60% loading conditions.
Figure 7. Variation of carbon di-oxide with respect to load

4. Conclusion:

Under the above engine performance we analysed the BTE is higher in B20E fuel 7.7% and lower in B10LG fuel 2%. BSFC higher in B20CH and lower in B20E. CO emissions are higher in B10CSO, HC emission are higher in B20CSO, B20LG higher in NOx emissions and lower in B10CH fuel CO2 emission is higher in B20CSO and lower in CO2 emissions. These are results obtained from the performance of engines. From the above analysis fuel B20E produces better performance for the IC engines.

5. Reference:

[1]. Alpaslan Atmanlı et al. Experimental investigation of engine performance and exhaust emissions of a diesel engine fueled with diesel–n-butanol–vegetable oil blends. Energy Conversion and Management 81 (2014) 312–321.

[2]. D.C. Rakopoulos. Combustion and emissions of cottonseed oil and its bio-diesel in blends with either n-butanol or diethyl ether in HSDI diesel engine. Fuel 105 (2013) 603–613

[3]. S. Baipai, P.K et al. Feasibility of blending karanja vegetable oil in petro-diesel and utilization in a direct injection diesel engine. Fuel 88 (2009) 705–711

[4]. Sangeeta et al. Alternative fuels: An overview of current trends and scope for future. Renewable and Sustainable Energy Reviews 32 (2014) 697–712

[5]. Soo-Young No. Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: A review. Renewable and Sustainable Energy Reviews 15 (2011) 131–149

[6]. Senthil Raja, Performance emission and combustion characteristics of a dual fuel engine with Diesel-Ethanol-Cotton seed oil Methyl ester blends and compressed Natural gas (CNG) as fuels (2016)

[7]. Experimental study of effect of isobutanol in performance, combustion and emission characteristics of CI engines fuelled with Cotton seed oil blended diesel (2017)

[8]. Impact of fuel injection pressure and and compression ratio on performance and emission characteristics of VCR CI engine fuelled with palm-kernel oil eucalyptus oil blends (2017)
[9]. Performance and emission characteristics of diesel engine fuelled with camphor oil - Diesel blends (2016)

[10]. Lemon peel oil - A novel renewable alternative energy source for diesel engine (2017)