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Experimental Investigation of Performance Characteristics and Exhaust Emissions of a CI Engine Fuelled With Mixed Blends of Ethanol and Cotton Seed Oil Biodiesel

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Abstract: There is a shortage of crude oil in the current world scenario and the rise of automobile usage is increasing rapidly. Also, the harmful emissions released by the vehicles are creating the global warming. In order to reduce these negative effects and utilize the existing fleet of vehicles, biodiesel is the essential replacement to the conventional diesel. Even the blended fuel will improve the performance and reduce the harmful emissions. In the current research, biodiesel is prepared from cotton seed oil through transesterification process. The cotton seed oil biodiesel which is prepared from transesterification is blended with diesel and ethanol and that blended fuels in different proportions are tested in diesel engine for performance and emission analysis. The fuel blends tested for the current work are diesel and cotton seed oil biodiesel CSOB10D90 (Cotton seed oil biodiesel 10 % + Diesel90%), CSOB20D90 (Cotton seed oil biodiesel 20 % +Diesel 80 %) and blends of cotton seed oil biodiesel, ethanol and diesel are used in the proportion of CSOB5E5D90 (Cotton seed oil biodiesel 5 % + Ethanol 5% +Diesel 80 %) and CSOB10E10D80 (Cotton seed oil biodiesel 5 %+ Ethanol 5% +Diesel 80 %) and diesel fuel. Experiment has been carried out at loading conditions from no load to the full load conditions for all mixed fuel blends along with diesel fuel. From Comparative analysis it is clear that, Hydro Carbons (HC) and Carbon Monoxide (CO) emissions are significantly reduced and Oxides of Nitrogen NOx emissions are moderately increased for all mixed fuel blends when compared with diesel fuel. The performance characteristics, Brake thermal efficiency and Brake specific fuel consumption is enhanced for Ethanol blended with cotton seed oil biodiesel fuel blend when compared with all mixed fuel blends and diesel fuel.

Keywords: CI Engine, Cotton seed oil biodiesel, Ethanol, Brake thermal efficiency Emissions, BSFC.

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1 Introduction

In order to meet the world energy demand fossil fuel usage is the key factor. As this energy is utilized for the development of socio activities, welfare activities thus by improving the quality of life. However, rapid rise of industrialization and modernization creates huge amount of demand for energy in and around. This fossil fuel usage leads to drastic effect of environment and fossil fuel is known as fast depleting energy resource. Due to these reasons, the world is looking for renewable energy resources to reduce the global warming and slowly reduce the usage of fossil fuels. In this regard, CI (Compression Ignition) engine is with a huge role with everyday transportation network. Diesel fuel is mainly utilized as the fuel in CI engines. CI (Compressed Ignition) engine plays a crucial role in automotive sector. However, due to increase of depletion of diesel fuel and high costs forced the automotive sector to look for alternative fuels. CI engine generally exhibits maximum power output at lower levels of fuel intake within the usage of off – road vehicles such as trucks and considered to be advantageous. Compression Ratio (CR) and the injection timing of the fuel leverages a great impact in the combustion process of the CI engine which operates with high compression engine. In the current industrial sector, CI engine is the key driver of the society. This paper is focused on the performance characteristics and emission characteristics of the CI engine fueled with Ethanol blend and mixed with biodiesel fuel. CI engine powered with alternative fuel is a wide research and few researches states that usage of alternative fuel in the existing engine would be advantageous and reduce the emissions and rise in transportation ease, which is the key factor for today's high living standard.

2 Literature Survey

H.Aydin et al [1] investigated the effect of cottonseed oil methyl ester-diesel fuel blends (B5, B20 and B50), B100 and diesel fuel on engine performance and exhaust emissions using cotton seed oil methyl ester as fuel blend in compression ignition engine For full load engine operation, at lower engine speed the bsfc of B20 were observed lower than those of other fuels including diesel fuel. It may be due to the fuel based oxygen and higher cetane number, leading to more complete combustion at low speeds and the CO emissions decreased with biodiesel usage. Reduced CO emissions were maintained, probably, thanks to the oxygen inherently present in CSOME. Shyam Kumar Ranganathan et al [2] evaluated performance of CI engine using cotton seed oil methyl esters. The experiment was carried out varying load at constant speed. The results revealed that preheating COME up to 90oC at higher load lead to increase in brake thermal efficiency is 2 % as compared to diesel fuel and brake specific fuel consumption increases at higher load as compared to diesel fuel. K Dilip kumar et al [3] conducted experiments on CI engine using Cotton seed oil and Neem oil Methyl esters as fuel blends from their work they concluded that there was increase in brake thermal efficiency Of CSOME –C20 as compared to pure diesel because of complete combustion. It was observed that the smoke and emissions for the blends of CSOME and NOME are less as compared to pure diesel. Y.H Teoh et al [4] conducted experiments on CRD engine using Bioethanol as additive in coconut oil biodiesel, results obtained shown improvement in the Brake specific fuel consumption and Brake thermal efficiency of the blends at the expense of Brake specific fuel consumption cam be observed for each

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bioethanol blend also higher % of ethanol in the blend causes an increment in the NOx emission over the entire load. Khoobbakht et al [5] prepared fuel blends of diesel-ethanol-biodiesel produced from waste cooking oil, and they demonstrated the optimization of the exhaust emissions from a Diesel engine using response surface methodology. Test results showed that biodiesel and ethanol reduced CO, HC, NOx, and smoke opacity and increased CO_2.Mofijur et al [6] also worked on a review of the role of] ethanol- biodiesel-diesel blends on the reduction of diesel emissions. The conclusions of this review showed that ethanol-biodiesel-diesel blends reduce the PM, HC, and CO emissions, but that these blends increase NOx and CO2 emissions.

The current paper highlights the characteristics of the engine performance for mixed fuel blends of Cotton seed oil biodiesel and diesel CSOB10 D90 (Cotton seed biodiesl 10 % + Diesel 90 %), CSOB20 D90 (Cotton seed biodiesel 20 % +Diesel 80 %), and cotton seed oil biodiesel, ethanol and diesel fuel blends CSOB5 E5 D90 (Cotton seed biodiesel 5 % + Ethanol 5% +Diesel 90 %) and CSOB10 E10 D80 (Cotton seed biodiesel 10 % + Ethanol 10% +Diesel 80 %) used in a single cylinder diesel engine at speed of 1500 rpm in six different loads. With similar conditions, Emission characteristics are evaluated.

3 Fuel Properties

3.1 Flash point

Flash point is the lowest temperature at which the petroleum products i.e.., petrol or diesel fuel will form a vapor in the air near its surface that will flash or briefly ignite on exposure to an open flame. Flash point is the general indication of flammability or combustibility of liquid fuels. Here in this work Cleveland open cup tester ASTM D92: ISO 2592 is used.

3.2 Fire point

Fire point of a fuel is the lowest temperature at which the vapor of the that fuel will continue to burn for at least 5 seconds after ignition by an open flame. Fire point is usually greater than flash point. In the present work Cleveland open cup tester ASTM D92: ISO 2592 is used

3.3 Kinematic Viscosity

Kinematic viscosity is a measure of fluids internal resistance to flow under gravitational forces. It is determined by measuring the time in seconds, required for a fixed volume of fluid to flow a known distance by gravity through a capillary within a calibrated viscometer at a closely controlled temperature. Here in this work Redwood Viscometer 1 and 2 are used for measuring viscosity of fuel blends, from constants obtained from viscometers kinematic viscosity is obtained.

3.4 Calorific Value

Calorific value of the fuel is the amount of energy released or produced when one kg of fuel is burnt completely in the presence of oxygen. Here in this work bomb calorimeter is used to find out calorific values of diesel, ethanol and cotton seed oil biodiesel.

Table 1 Properties of fuels

Sl. No.	Fuel	Density Kg/m^3	Kinematic Viscosity (centistoke)	Flash Point (°C)	Calorific Value (KJ/Kg)
1	Diesel	828	2.6	56	43,852
2	Ethanol blend	788	1.1	13	27,000
3	Cotton seed oil Biodiesel	865	4.6	199	39,275

4 Experimental Engine Setup

The test is conducted on single cylinder, 4 stroke, water cooled, Compression Ignition Engine of kirloskar make. Experiment is conducted on 5 different loading conditions and loading is done by eddy current dynamometer load cell. Gas Analyzer of AVL make is connected at the end of exhaust manifold for finding out emission parameters. Experiment is conducted for mixed fuel blends and diesel fuel.

.Figure 1 Experimental Engine Setup

Table 2 Test engine technical specification

Manufacturer	Kirloskar Oil Engine Ltd.
BHP	5 HP
Speed	1500 rpm
Number of Cylinders	One
Compression ratio	16.5:1
Bore Diameter	80 mm
Length of Stroke	110 mm
Type of Loading	Eddy current dynamometer
Method of Starting	Crank Start
Method of Cooling	Water Cooling
Method of Ignition	Compression Ignition

4.1 Performance parameters

Performance test was conducted for different fuel blends of cotton seed oil biodiesel and diesel (CSOB10 D90, CSOB20 D80) and cotton seed oil biodiesel, ethanol and diesel blends (CSOB5 E5 D90, CSOB10 E10 D80). Initially test was conducted for diesel fuel and compared with all mixed blend values. Different engine parameters like Brake power, Brake specific fuel consumption, Brake thermal efficiency, Indicated power, Indicated thermal efficiency and mechanical efficiency are obtained and results were plotted with respect to all loading conditions.

5. Results & Discussion

5.1 Brake thermal efficiency (BTE)

The brake thermal efficiency indicates how well an engine convert heat energy from the fuel to the mechanical energy. It is also defined as brake power of heat engine as function of thermal input from the fuel. It was observed that brake thermal efficiency increases with increase in the load. This is due to increase in power developed and reduction in heat losses with increase in load. Brake thermal efficiencies of the fuel blends CSOB10 D90, CSOB20 D80 and CSOB5 E5 D90, CSOB10 E10 D80 has been increased up to 1 to 2% at all load conditions when compared with conventional diesel fuel. This increase in efficiencies is due to the presence of optimum level of oxygen in the cotton seed oil biodiesel and ethanol which will contribute to proper combustion.

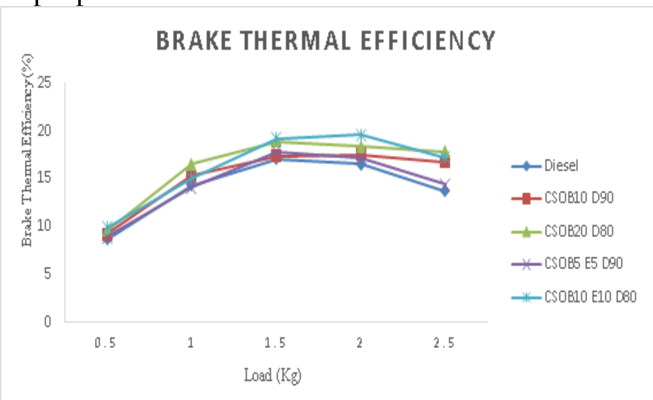

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Figure 2 Brake thermal efficiencies of mixed fuel blends and diesel at various loading conditions

5.2 Brake specific fuel consumption

The consumption of fuel to generate the power in unit time is determined as brake specific fuel consumption and termed as crucial factor for any given engine. It is typically used for comparing the efficiencies of internal combustion engines with a shaft output. The brake specific fuel consumption decreases with increase in load for all the blends and increases with increase in % of biodiesel in the fuel blend. It was found in present work Bsfc decreased for all mixed blends when compared with diesel as shown in figure 3. This may be due to the optimum % of oxygen present in the blend, which might give better combustion in addition to optimum viscosity (lacking with neat diesel), leading to reduced fuel consumption. For ethanol mixed blends also brake specific fuel consumption is lower compared to diesel this also because of the fact that ethanol contains high amount of oxygen which will improve combustion.

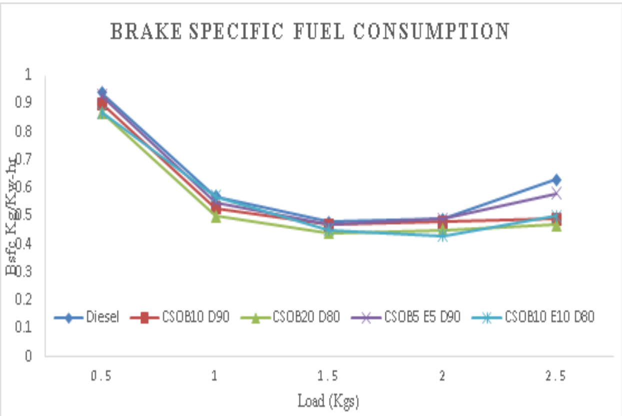

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Figure 3 BSFC of mixed fuel blends and diesel at various loading conditions.

5.3 Emission Characteristics

The exhaust gases are analyzed with the gas analyzer and the recorded emissions are Carbon Monoxide (CO), Hydrocarbons (HC), and Nitric Oxide (NO).

5.3.1 Carbon Monoxide (CO)

Carbon monoxide results from incomplete oxidation of the carbon particles in the fuel as a result of inadequate amount of oxygen for the complete oxidation, means due to incomplete oxidation. As the cotton seed oil biodiesel is oxygen rich fuel, therefore results in reduced carbon monoxide emissions for the blends of CSOB10 D90 and CSOB20 D80 when compared to diesel fuel. When coming to the CO emissions for ethanol, cotton seed oil biodiesel and diesel mixed blends (CSOB5 E5 D90, CSOB10 E10 D80) has been reduced significantly compared to the diesel fuel this is because of rich oxygen content of ethanol. The figure 4 shows the significant reduction of CO for all mixed fuel blends when compared to diesel fuel.

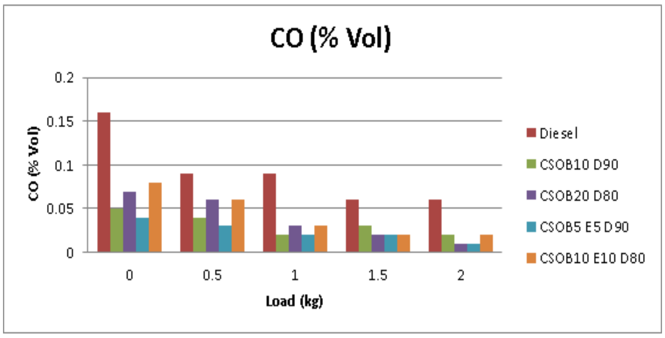

Figure 4 CO emission values of mixed fuel blends and diesel at various loading conditions

5.3.2 HC Emissions

The unburnt hydrocarbons also referred as hydro carbons (HC) are the results of incomplete combustion of the fuel. When the combustion takes place there will be some of unburnt fuel where the flame will not reach due to this emission of unburnt hydrocarbons

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will take place. Figure 5 represents the variation of Hydrocarbons with respect to load. There is significant reduction in unburnt hydrocarbons using cotton seed oil biodiesel and diesel (CSOB10 D90, CSOB20 D80) blends and cotton seed oil biodiesel, ethanol and diesel (CSOB5 E5 D90, CSOB10 E10 D80) when compared to conventional diesel fuel.

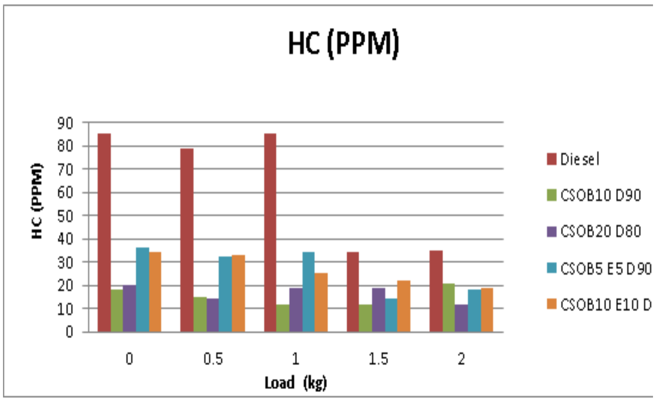
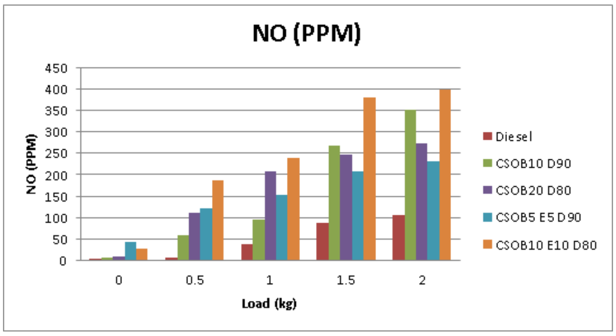


Figure 5 HC emission values of mixed fuel blends and diesel at various loading conditions

NO Emission

The oxides of nitrogen emitted from the diesel engines are in the form of NO and are oxidized to NO_2 within short time. Approximately 10 to 20% of nitrogen oxides from diesel engine are emitted as NO_2(nitrogen oxide) which is five times more toxic than NO. Nitric oxide (NO) and nitrogen dioxide (NO_2) are collectively called as oxides of nitrogen (NOx). Nitrogen oxides are produced when the nitrogen reacts with excess oxygen at high temperatures. As the blends of cotton seed oil biodiesel and diesel (CSOB10 D90, CSOB20 D80) and cotton seed oil biodiesel, ethanol and diesel blends (CSOB5 E5 D90, CSOB10 E10 D80) contains more amount of oxygen than diesel fuel so there is a significant increase in the amount of oxides of nitrogen for all the mixed fuel blends when compared to diesel.

Figure 6 NO emission values of mixed fuel blends and diesel at vario



us loading conditions

5 Conclusion

In this experimental study, the effect of mixed fuel blends of cotton seed oil biodiesel and diesel, and cotton seed oil biodiesel, ethanol and diesel mixed blends are used for investigation of performance and exhaust characteristics. The performance characteristics are done along with the diesel fuel and the results obtained mixed fuel blends are compared with diesel fuel. The following conclusions are made

1. For the fuel blend cottonseed oil biodiesel and diesel (CSO B20 D80), brake thermal efficiency is displayed at 80% load conditions is recorded as 18.4% which is 1% better than conventional diesel fuel.
2. At 80% of load, the brake thermal efficiency of the biodiesel fuel mixed with ethanol and diesel (CSO B10 E10 D80) is recorded as 19.6 % which is 2% higher than conventional diesel fuel. This is due to the concentration of three fuels in mixed biodiesel blend and rich content of oxygen in the fuels. Brake thermal efficiencies of all mixed fuel blends have been increased

when compared to diesel fuel at all loading conditions.

3. Low brake specific fuel consumption is observed for all mixed fuel blends when compared to diesel fuel, which states that as the load increases complete combustion takes place, which assists in low fuel consumption and power produced is maximum.
4. Emissions CO, HC are significantly reduced for all mixed fuel blends at all loading conditions when compared to diesel fuel. NOx emissions are increased for all mixed fuel blends at all loading conditions when compared to diesel fuel.

References

1. H. Aydin, H. Bayindir, Performance and Emission Analysis of Cotton seed oil methyl ester in a diesel engine, Renewable energy 35 (2010) 588-592.
2. Shyam Kumar Ranganathan, Anil Gandamwad. Mayur Bawankure, Performance Evaluation of CI Engine with Cotton seed oil, International Journal of Instrumentation, Control and Automation (IJICA) ISSN:2231-1890, Vol-1, Issue-3,4, 2012.
3. K. Dilip Kumar, P. Ravindra Kumar, Experimental Investigation of Cotton seed oil and Neem oil Methyl esters as Biodiesel on CI engine, International Journal of Modern Engineering and Research (IJMER) ISSN:2249-6645, Vol 2, Issue-4, July-August 2012, 1741-1746.
4. Y.H Teoh, R.H.Yu, H.G How, H-T Nguegen, Experimental Investigation of Performance, Emission and Combustion Characteristics Common Rail Diesel engine Fuelled with Bioethanol as Fuel additive in Coconut oil Biodiesel Blends, Energies 2019,12,1954.
5. Khoobbakht, G., et al., Optimization of Operating Factors and Blended Levels of Diesel, Biodiesel and Ethanol Fuels to Minimize Exhaust Emissions of Diesel Engine Using Response Surface Methodology, Applied Thermal Engineering, 99 (2016), 25, pp. 1006-1017.
6. Mofijur, M., et al., Role of Biofuel and their Binary (Diesel-Biodiesel) and Ternary (Ethanol-BiodieselDiesel) Blends on Internal Combustion Engines Emission Reduction, Renewable and Sustainable Energy Reviews, 53 (2016), Jan., pp. 265-278.
7. Milind A.Pelegade, Madhavi S.Harne, Dr Ramakanth Shrivastava, Performance evaluation of CI engine using cotton seed oil as alternative fuel, Science and Technology, IJSRST173684, Volume3 2017, print ISSN2315-6011.
8. Sastry, G. R. K., et al., Effect of Fuel Injection Pressure, Isobutanol and Ethanol Addition on Performance of Diesel-Biodiesel Fuelled DI Diesel Engine, Energy Procedia, 66 (2015), 2015, pp. 81-84
9. Alptekin, E., et al., Using Waste Animal Fat Based Biodiesels-Bioethanol-Diesel Fuel Blends in a DI Diesel Engine, Fuel, 157 (2015), 1, pp. 245-254.
10. Sayin, C., Engine performance and exhaust gas emissions of methanol and ethanol–diesel blends. Fuel, 89(11), 3410–3415. doi:10.1016/j.fuel.2010.02.017
11. Jazair W, Kubo S, Takayasu M, Yatsufusa

T, Kidoguchi Y, Performance and emission characteristics of a diesel engine fueled by rapeseed oil bio-fuel. J Mekanikal 2011;33:32–9

12. Gumus, M., Sayin, C., &Canakci, M., The impact of fuel injection pressure on the exhaust emissions of a direct injection diesel engine fueled with biodiesel–diesel fuel blends. Fuel, 95, 486–494. doi:10.1016/j.fuel.2011.11.020
13. Atmanlı, A., Yüksel, B., &İleri, E, Experimental investigation of the effect of diesel–cotton oil–n-butanol ternary blends on phase stability, engine performance and exhaust emission parameters in a diesel engine. Fuel, 109, 503–511. doi:10.1016/j.fuel.2013.03.012.
14. Ashok B, Nanthagopal K, Anand V, Aravind KM, Jeevanantham AK, Balusamy S, Effects of n-octanol as a fuel blend with biodiesel on diesel engine characteristics. Fuel 2019;235:363–73.
15. Thiyagarajan S, Sonthalia A, Geo VE, Prakash T, Karthickeyan V, Ashok B, Effect of manifold injection of methanol/n-pentanol in safflower biodiesel fuelled CI engine. Fuel 2020;261:116378.
16. Huang H, Guo X, Huang R, Lei H, Chen Y, Wang T, Effect of n-pentanol additive on compression-ignition engine performance and particulate emission laws. Fuel 2020;267:117201.
17. Atmanli A, Yilmaz N, A comparative analysis of n-butanol/diesel and 1-pentanol/ diesel blends in a compression ignition engine. Fuel 2018;234:161–9.
18. Shrivastava P, Verma TN, Effect of fuel injection pressure on the characteristics of CI engine fuelled with biodiesel from Roselle oil. Fuel 2020;265:1.