Performance And Emission Characteristics Of Direct Injection Diesel Engine Using Bio-Diesel With Scr Technology

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Abstract

In this study, the biodiesel produced from cottonseed oil was prepared by a method of Transesterification and its blends of 25%, 50%, 75% and 100% in volume, and standard diesel fuel separately. The effects of biodiesel addition to diesel fuel on the performance, emissions and combustion characteristics of a naturally aspirated DI compression ignition engine were examined. Biodiesel has different properties from diesel fuel. A minor increase in specific fuel consumption (SFC) and reduced brake thermal efficiency (BTE) for biodiesel and its blends were observed compared with diesel fuel. The significant improvement in reduction of Hydrocarbon (HC) and smoke emission were found for biodiesel and its blends at high engine loads. Carbon monoxide (CO) had no evident variation for all tested fuels. Nitrogen oxides (NO_x) were slightly higher for biodiesel and its blends. The significant improvement in reduction of NO_x and a minor increase in CO_2 and O_2 were identified use of selective catalytic reduction (SCR).Biodiesel and its blends exhibited similar combustion stages to diesel fuel. The use of transesterified cottonseed oil can be partially substituted for the diesel fuel at most operating conditions in terms of the performance parameters and emissions without any engine modification.

Keywords-Diesel Particulate Filter, Selective Catalytic Reduction, Oxides of Nitrogen, Environment Protection Agency, Hydro Carbons, Nitrogen Oxide, Nitrogen-di-Oxide

INTRODUCTION

One of the most important elements to effect world economy and politics is sustainability of petroleum resources, which is the main source of world energy supply. However, the world energy demand is increasing rapidly due to excessive use of the fuels but because of limited reservoirs and instabilities in petrol supplier countries makes difficult to always provide oil. Also, world is presently confronted with the crisis of fossil fuel depletion. The petroleum crises since 1970s and uncertain situation in suppliers like Venezuela, Nigeria, and Iraq have accelerated the increment of oil prices. The increasing demand of petroleum in developing countries like China, Russia and India has increased oil prices. Besides, the combustion of petroleum based fuels causes environmental problems, which threatens wild life and human life, impacts on the environment and human health. In addition, the combustion products cause global warming one of the most important world problem.

The global warming is caused of emissions like carbon monoxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NOx). In power system of using petroleum fuels, these components are emitted through the combustion process. Concerning environmental damage the transport sector has a clear responsibility. Its part in global warming potential has increased from year by year and now bigger than those of the domestic and industrial sectors, while it highly constitutes the total emissions of this pollution type. Diesel engines are mainly used in many fields, including electric production, transport of passenger and cargo, industrial and agricultural activities.

Petroleum fuels are being used in diesel engines, which have a wide range of use in all sectors. With a probable situation that oil demand cannot be met by petroleum based fuels, all the sectors contributed by oil based energy will negatively be effected. With any probable petrol crisis, for all the sectors the alternative fuel is vital to be developed. In addition, pollutants have formed because of combustion of petroleum based fuels in diesel engines. Pollutants from diesel engines include carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxides (SOx), oxides of nitrogen (NOx) and particulate matter (PM). NOx and PM are the two primary pollutants of diesel engines. It was stated by Lloyd and Cackete, that Diesel emissions contribute to the development of cancer; cardiovascular and respiratory health effects; pollution of air, water, and soil; soiling; reductions in visibility; and global climate change. Research on reducing emissions resulted from diesel engines and studies on decreased fuel consumption are being founded worldwide, especially in EU countries. There are many works on reliable researching and implementations and useful results came to exist. Research and developing alternative diesel engine fuel is one of the aspects of these studies.

The alternative diesel fuels must be technically acceptable, economically competitive, environmentally acceptable and easily available. Researches on biodiesel derived from vegetable oils and animal fat are being maintained to alternate this kind of fuels to petroleum based diesel fuel. It has been concluded by many studies that as an alternative engine fuel biodiesel reduces the emissions of carbon monoxide (CO), hydrocarbon (HC), sulphur dioxide (SO_2), polycyclic aromatic hydrocarbons (PAH), nitric polycyclic aromatic hydrocarbons (nPAH) and particulate matter (PM) but NOx to increase in the exhaust compared with diesel fuel. Biodiesel has higher cetane number than diesel fuel, no aromatics, almost no sulphur, contains high oxygen by weight, non-toxic, biodegradable and high lubricant abilityare its attractive properties. Although biodiesel has many advantages, it still has several properties, needed to be improved, such as lower calorific value, lower effective engine power, higher emission of NOx, and greater sensitivity to low temperatures.

The choice of vegetable oil as engine fuel naturally depends upon the local conditions prevalent availability of a particular vegetable oil in excess amount. There are various oils which are being considered worldwide for use in the engines, these include Karanja oil, Rice bran oil, Sunflower oil, Soyabean oil, Pape seed oil, Madhucalatifolia oil, Jatropha oil and etc. From previous studies it is evident that these are various problems associated with vegetable oil, being used as fuel in C.I. Engines. There are mainly caused by the high viscosity value of the vegetable oil. This higher viscosity is due to free fatty acid present in the oil. This free fatty acid is due to large molecular mass and chemical structure of vegetable oil, which in turn leads to problem in pumping, combustion and atomization on C.I engines therefore it is necessary to reduce the free fatty acid and viscosity of vegetable oil to make it suitable as an alternative fuel for diesel engine. The various methods which have been enough to use vegetable oil efficiently some of them are,

1. Transesterification process
2. Pre heating the oil
3. Blending with diesel
4. Use of additives
5. Pyrolysis

In this project work, Transesterification process has been taken as a process for conversion of vegetable oil to biodiesel. Before Transesterification process, the sum amount of free fatty acid present in the oil has been estimated in the presence of monoglycerides and triglycerides. In this process the triglycerides in the vegetable oil are converted to their mono esters by reacting it with alcohol in the presence of a Potassium hydroxide (KOH) as a catalyst.

BIODIESEL

Biodiesel is methyl or ethyl ester of fatty acid made from virgin or used vegetable oils (both edible and non-edible) and animal fat. The main sources for biodiesel production can be non-edible oils obtained from plant species such as Jatrophacurcas (Ratanjyot), Pongamiapinnata (Karanj), Calophylluminophyllum (Nagchampa), Hevcabrasiliensis (Rubber) etc. Biodiesel can be blended in any proportion with mineral diesel to create a biodiesel blend or can be used in its pure form. Just like petroleum diesel, biodiesel operates in compression ignition (diesel) engine, and essentially requires very little or no engine modifications because biodiesel has properties similar to mineral diesel. It can be stored just like mineral diesel and hence does not require separate infrastructure. The use of biodiesel in conventional diesel engines results in substantial reduction in emission of unburned hydrocarbons, carbon monoxide and particulate. This review focuses on performance and emission of biodiesel in CI engines, combustion analysis, wear performance on long-term engine usage, and economic viability.

BIO DIESEL AS ALTERNATE FUEL

Bio diesel is the name of clean burning fuel, produced from domestic renewable resources. It contains no petroleum but it can be blended with at any level with petroleum diesel to greater biodiesel blend. It can be used in CI engine with no major modifications. It is simple to use, bio degradable, non-toxic and essentially free of sulphur and aromatics.

CHEMISTRY OF BIODIESEL

Chemically it is defined as the mono esters of long chain fatty acids derived from renewable lipid source. It is typically produced through the reaction of oil or animal fat with methanol or ethanol in presence of catalyst to yield glycerin and biodiesel. It can be used in neat from or blended with diesel for use in diesel engine their physical and chemical properties as relates to diesel fuel.

NEED OF BIODIESEL

For more than two countries, the world energy supplying has relied heavily on non-renewable crude oil derived (fossil) liquid fuels out of which 90 % is estimated to be consumed for energy generation and transportation. It is also known that emissions from the combustion of these fuels are the principal causes of global warming and many countries have passed legislation top arrest their adverse environmental consequences with population increasing rapidly and many developing countries expanding their industrial base and output, worldwide energy demand is bound to increase on the other hand, known crude oil reserves cloud be depleted in less than 50 years at the present rate of consumption. This situation initiated and has sustained interest in identifying and channeling renewable raw materials into the manufacture of liquid fuel alternatives because development of such biomass based power would ensure that new technologies are available to keep pace with society need for new renewable power alternative for future.

Oil seed crops are by far the largest group of exploitable renewable biomass resource for liquid fuel and energy generation.

SAFETY CONCERNS

Biodiesel is safer to use than petroleum diesel. The flash point and fire point for biodiesel in its pure form is more than 148 °C versus 52 °C for regular diesel although firs are not frequent occurrence on locomotives yet if they occur than they devastating.

EASY ADAPTABILITY

Just like petroleum diesel biodiesel operates in combustion ignition engines. Essentially no engine modifications are required and it materials the pay load capacity and range of diesel.

EMISSION REDUCTIONS FROM BIODIESEL

Biodiesel reduces PM significantly. The use of biodiesel in conventional diesel engines result in substantial reduction of un burned HC, CO and PM. Since biodiesel is oxygenated, engines have more complete combustion than with ordinary diesel

PARTICULATE MATTER (PM)

PM emissions from biodiesel are 30% lower than overall PM emissions from diesel.

HYDROCARBONS (HC)

The total hydrocarbons exhaust emissions of (a contributing factor in the localized formation of smog and Ozone) where 93% lower for biodiesel than diesel fuel.

NITROGEN OXIDES (NOX)

NOx emission is from biodiesel increases or decreases depending on the engine family and testing procedures. NOx emission is (a contributing factor in the localized formation of smog and Ozone) from biodiesel increased by 13 %. However, biodiesel lack of sulphur allows the use of NOx control technologies that cannot be used with conventional diesel. So biodiesel NOx technologies are can be effectively eliminated as a concern of the fuels use.

SMOG FORMATION

The overall ozone (smog) forming potential of biodiesel is less than diesel fuel. The ozone forming potential of hydrocarbon emission is nearly 50% less than that measured for diesel fuel.

SULPHUR EMISSIONS

The exhaust emission of sulphur oxides and sulphates (major components of acid rain) form biodiesel are essentially eliminated compared to sulphur oxides and sulphates from diesel.

CARBON MONOXIDES

The exhaust emissions of carbon monoxide (a poisonous gas) from biodiesel are 50% lower than from the diesel engine.

OBJECTIVE AND METHODOLOGY

OBJECTIVE

The objective of the present work is to evaluate performance, emission and combustion on DI diesel engine run on different blends of biodiesel with sole fuel

1. Selecting suitable raw oil for producing biodiesel.
2. To ascertain the stability of the blends.
3. To analyze the physical and chemical properties of blends.
4. The blending ratio of biodiesel and diesel are B25, B50, B75and also B100 will be used.
5. Conducting the experiments with necessary equipment to study the performance, emission and Combustion characteristics in diesel engine using biodiesel blended fuel.
6. To find the best blend rate of the fuels based on the performance, combustion and emission.

METHODOLOGY

1. Bio diesel is prepared from raw oil by transesterification process.
2. The engine was allowed to run with sole fuel at constant speed for nearly 10 minutes to attain the steady state condition at the lowest possible load and experimental procedure is done
3. The experimental procedure is repeated with B100 and also various blend ratios of bio-Diesel (B25, B50 and B75 by volume).
4. The exhaust emissions like CO, HC, CO_2, O_2 and NOx are measured with the help of an AVL DI Gas analyzer.
5. Smoke density is measured by AVL smoke meter.
6. AVL combustion analyzer is used to measure the combustion characteristics of the engine.

THE BIODIESEL PRODUCTION AND CHARACTERIZATION

BIODIESEL PRODUCTION PROCEDURE

The biodiesel fuel used in this study was produced from the transesterification of raw cottonseed oil with methanol (CH_3OH) catalyzed by potassium hydroxide (KOH). A titration was performed to determine the amount of KOH needed to neutralize the free fatty acids in raw cottonseed oil. The amount of KOH needed as catalyst for every liter of raw cottonseed oil was determined as 12 g. For transesterification, 210 mL CH_3OH plus the required amount of KOH were added for every liter of raw cottonseed oil, and the reactions were carried out at 450C. The water wash process was performed by using a sprinkler which slowly sprinkled water into the biodiesel container until there was an equal amount of water and biodiesel in the container. The water biodiesel mixture was then agitated gently for 20 min, allowing the water to settle out of the biodiesel. After the mixture had settled, the water was drained out.

BIODIESEL PROPERTIES

A series of tests were performed to characterize the compositions and properties of the produced biodiesel. The fuel properties of biodiesel and its blends with diesel fuel are shown in Table 1. It is shown that the viscosity of biodiesel is evidently higher than that of diesel fuel. The density of the biodiesel is approximately 6.02% higher than that of diesel fuel. The lower heating value is approximately 9.08% lower than that of diesel fuel. Therefore, it is necessary to increase the fuel amount to be injected into the combustion chamber to produce same amount of power. Fuels with flash point above 520C are regarded as safe

Properties of biodiesel in comparison with commercial diesel and best blends

PROPERTIES	DIESEL	B 50	B100
Density @ 15 °C in gm/cc	0.8344	0.8610	0.8835
Specific gravity @ 15° /15°C	0.8360	0.8610	0.8848
Kinematic viscosity @ 40 °C (mm^2/s)	3.07	4.12	6.83
Flash point (°C)	60	108	150
Fire Point (°C)	69	118	161
Cloud Point (°C)	15	21	27
Calorific value (kJ/kg)	44125	43124	40789
Cetane Number	51	52	52

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Thus, biodiesel is an extremely safe fuel to handle compared to diesel fuel. Even 25% biodiesel blend has a flash point much above that of diesel fuel; making biodiesel a preferable choice as far as safety is concerned. The analysis results of cold filter clogging temperature, a criterion used for low temperature performance of the fuels, suggest that the performance of biodiesel is as good as diesel fuel in cold surroundings. With the increase of biodiesel percentage in blends, solidifying point of blends increases.

EXPERIMENTAL SET UP AND PROCEDURE

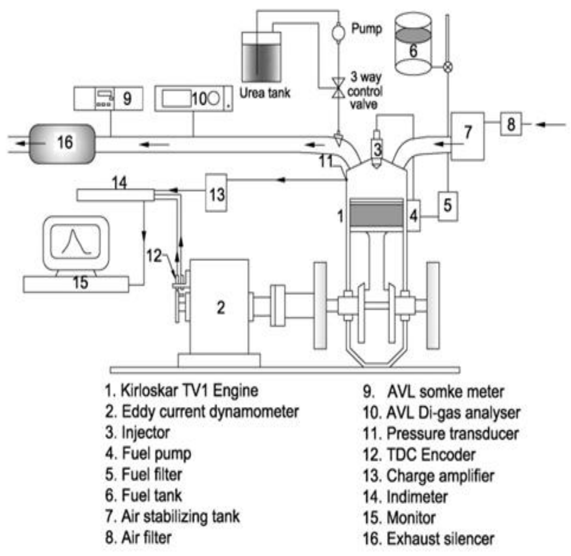
EXPERIMENTAL SET UP

The project work is done using biodiesel and diesel blends on single cylinder engine. The diesel engine is operated with different bio diesel blends.An experimental set up was configured with necessary instruments to evaluate the emission and combustion parameters of the compression ignition engine at different operating conditions. Single cylinder water-cooled four-stroke direct injection diesel engine Kirloskar TV-I, injection timing 220 kg/cm^2, compression ratio of 17.5:1, developing 5.2 kW at 1500 rpm was used for this work.

Specifications of the test engine

Make	Kirloskar TV- 1 Engine
Type	Single cylinder vertical water cooled 4 Stroke Diesel engine
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5:1
Fuel	Diesel engine
Rated brake power	5.2 kW(7HP)
Speed	1500 rpm
Ignition system	Compression Ignition
Ignition timing	23°bTDC (rated)
Injection Pressure	220 kgf/cm^2
Loading Device	Eddy current dynamometer
Orifice Diameter	0.02m
Dynamometer arm length	0.195 m

Details of the engine are given in Table 8.1 for the vertical water cooled single cylinder, four stroke, direct injection engine was used in the study. The engine coupled to an eddy current dynamometer for load measurement. Fuel flow rate is obtained on the gravimetric basis and the airflow rate is obtained on the volumetric basis. NOx emission is obtained using an exhaust gas analyzer. AVL 437 smoke meter is used to measure the smoke density. AVL five-gas analyzer is used to measure the rest of the pollutants. AVL combustion analyser is used to measure the combustion characteristic of the engine. A burette is used to measure the fuel consumption for a specified time interval. During this interval of time, how much fuel the engine consumes is measured, with the help of the stopwatch. The experimental set up is indicated in figure.8.1. Experiments were carried out in different blend ratios. These were neat diesel, then using diesel blended with bio diesel at B20, B40, B60, B80 and finally B100 biodiesel.



Engine Test Rig

RESULTS AND DISCUSSION

PERFORMANCE PARAMETERS

1. SPECIFIC FUEL CONSUMPTION

Figure (a) shows that variation of SFC with brake power for various biodiesel blends. All the blends slightly increase the SFC when compared to diesel. This may be due to better combustion, and an increase in the energy content of the blends.

2. BRAKE THERMAL EFFICIENCY

Figure (b) shows variation of Brake thermal efficiency with brake power for various biodiesel blends. There is no change up to part load conditions beyond that the brake thermal efficiency slightly increases, when compared to all the blends. The B100 shows the maximum Brake thermal efficiency around 3%.

EMISSION PARAMETERS

1. SMOKE DENSITY

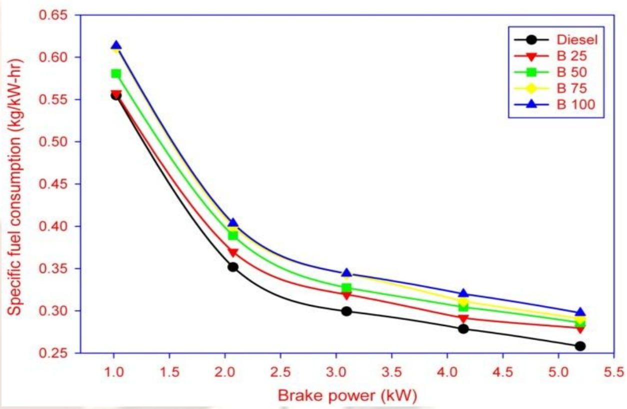
The variation of smoke emission at different blends of biodiesel is shown in figure 9.3. The significant reduction in smoke emission may be due to the oxygenated blends. Smoke is mainly produced in the diffusive combustion phase; the oxygenated fuel blends lead to an improvement in diffusive combustion for the B100 blend. Reduction in smoke emission of about 25% was recorded at full load for the B100 blend.

2. OXIDES OF NITROGEN

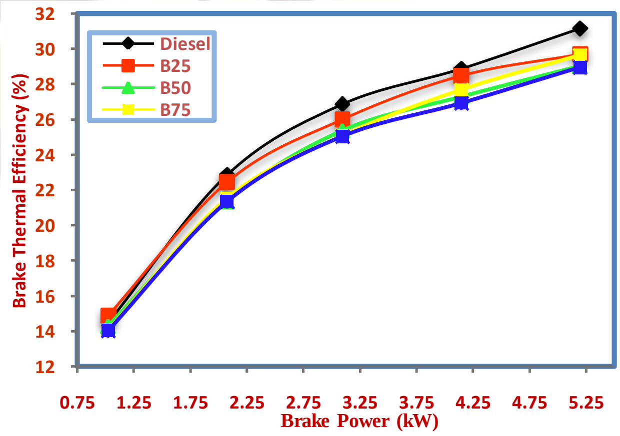
Figure (c) shows variation of oxides of nitrogen with brake power for various biodiesel blends. All the blends slightly increase the NOx emission. The B50 shows the maximum increase of NOx emission when compared to diesel and other blends. Because bio-diesel has higher oxygen it promotes the combustion.

OXIDES OF NITROGEN (SCR)

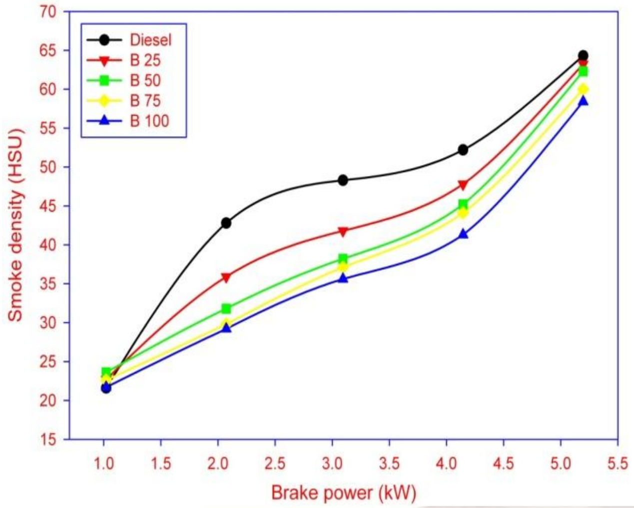
NOx emission of biodiesel and its blends are slightly higher than those of diesel fuel. The higher temperature of combustion and the presence of oxygen with biodiesel cause higher NOx emissions, especially at high engine loads. However, the biodiesel with a higher cetane number had comparable NOx emissions with the diesel fuel. However to reduce the NOx emission the selective catalytic reduction (Urea) is sprayed in the exhaust pipe. The various percentages of urea sprayed in the engine exhaust to find the optimum percentage. Among the percentage the 30% urea gives the maximum reduction of NOx emission. Based on the trials experimental work was carried out with biodiesel and its blends. When urea is spraying in the exhaust pipe, it reacts with NOx and gives carbon dioxide and NOx-1. Hence, NOx is decreased and CO_2 level is slightly increased. Figure 9.5 shows the variation of NOx emission against brake power effect of Urea 30%.



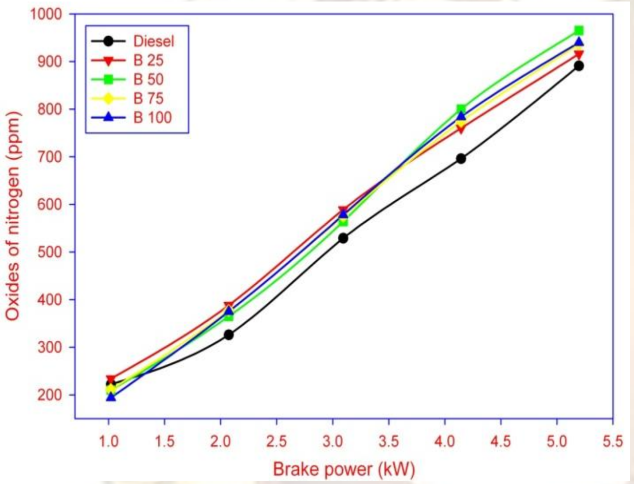
(a)Variation of SFC with brake power for various biodiesel blends



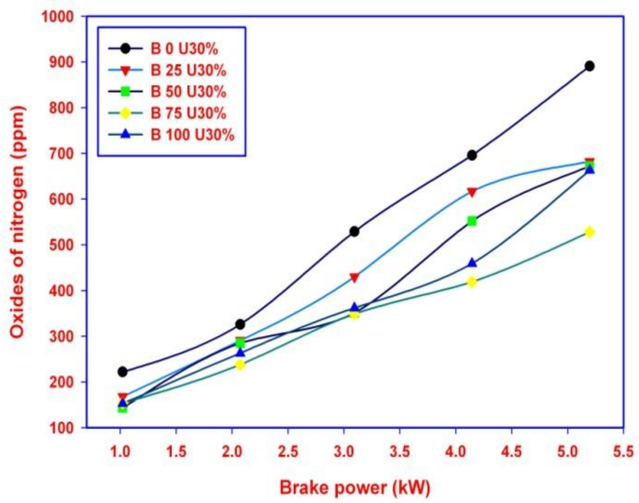
(b)Variation of Brake thermal efficiency with brake power for various biodiesel blends



(c)Variation of Smoke density with brake power for various biodiesel blends



(d)Variation of Oxides of nitrogen with brake power for various biodiesel blends



(e)Variation of Oxides of nitrogen with brake power effect of urea 30%

CONCLUSION

- The SFC increases with increase in percentage of biodiesel in the blends due to the lower heating value of biodiesel. The BTE of biodiesel and its blends are slightly higher than that of diesel at high engine loads, and keep almost same at lower engine loads.
- The oxygen content in the biodiesel results in better combustion and increases the combustion chamber temperature, which leads to higher NOx emissions, especially at high engine loads. The significant improvement in reduction of NOx and a minor increase in CO_2 were identified use of selective catalytic reduction (SCR).
- HC emissions of biodiesel and its blendes have little difference from diesel fuel. It is also observed that there is a significant reduction in CO and smoke emissions at high engine loads.
- The study tacitly suggests that excess oxygen contents of biodiesel play a key role in engine performance and biodiesel is proved to be a potential fuel for complete or partially replacement of diesel fuel. The combustion starts earlier for biodiesel and its blends than for diesel. The peak cylinder pressure of biodiesel and its blends is higher than that of diesel fuel, and almost identical at high engine loads. The peak pressure rise rate and peak heat release rate of biodiesel are higher than those of diesel fuel.

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