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Experimental Investigation On Single Cylinder LHR Diesel Engine Fueled With Bio Diesel Using EFI

Sekar J[#1], Dr. G. Anand Kumar[*2], Prabhu R[#3]

[#]ME - Department of Automobile Engineering, Madras Institute of Technology, Chromepet, Tamil Nadu, India.
[*]Assistant Professor - Department of Automobile Engineering, Madras Institute of Technology, Chromepet, Tamil Nadu, India.
[#]ME - Department of Automobile Engineering, Madras Institute of Technology, Chromepet, Tamil Nadu, India.

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Abstract

Diesel engines emits more hydrocarbon, carbon dioxide, carbon monoxide and oxides of nitrogen (NOx). The rapid depletion of conventional fossil fuels has promoted research towards alternative fuels for internal combustion(IC) engines. The tropical climatic condition in Asia favours the growth of Karanja which can be used as a feedstock for biodiesel through transesterification process. Due to their higher density and viscosity of bio diesel it need more heat to vaporize the fuel which can be achieved by LHR engine. The combustion components of the engine are coated with partially stabilized zirconia. The basic requirements of good thermal barrier coatings are low thermal conductivity, chemical inertness, experiencing same thermal expansion coefficient with metallic substrate and high melting point. In this work the injection pressure and its effects on the biodiesel are investigated. The conventional spring-loaded injector is used for making comparison with the advanced electronic fuel injection system. In this work Karanja oil is blended with diesel based on Mass fraction and performance and emissions are measured for B20. The result shows decreased emission of HC, CO, NOx and Smoke. The experiments are conducted in a constant speed engine with and without coating using diesel, biodiesel blends and 20%.

Keywords — *Biodiesel, Emissions, Fuel consumption, LHR engine, Performance.*

I. INTRODUCTION

Automobile has become a part of life of many people across the world. Diesel is one of the important fuels being used in vehicles for heavy transportations and also in passenger vehicle. The internal combustion engine with direct injection is widely used for vehicle with diesel fuel. All nations are concentrating on the factors that are responsible for global warming. Emission from automobile is one of the main factors of global warming. The health of people is also under concern because of air pollution caused by vehicle emission. The government is making strict norms for regulating the emission. The oil refineries are forced to produce fuel satisfying those norms. Apart from these diesel is a fossil fuel which is getting depleted. Therefore many researches are carried out across the globe to replace diesel with alternate fuel. Though there are many suggested alternative fuel like Hydrogen, Vegetable oil, Biodiesel, CNG etc. Each one has its own merits and demerits. India is focusing on the use of biodiesel to reduce the diesel consumption. Environment Protection Agency (EPA) of United States suggests that engine could be used for fuel blend up to 20% of biodiesel without any modification. The information on website of Hindustan petroleum reports, India's National Mission on Bio-diesel also targets on usage of 20% biodiesel blend on vehicles running on Indian roads. India supports biodiesel production from non-edible plant seeds like Jatropa, Karanja, and Mahua etc. The following content gives brief information about diesel and alternate fuels.

Diesel engines are high thermal efficiency machines, which are dependable, require lower conservation and have lower specific fuel consumption. Simultaneous decrease in NOx and particulate emissions from compression ignition (CI) engines is a main research trial being faced today due to massive pressure exerted by stringent emission norms being adopted world wide. Fuel injection at higher pressure and specific control of injection timing are helpful in dropping the engine out emissions. In the electronic fuel injection system, the fuel injection parameters such as fuel injection pressure, rate of fuel injection, multiple injections, and the start of injection (SOI)timings are controlled accurately by an electronic control unit (ECU)for different engine operating conditions.

Various types of electronic fuel injection systems used in CI engines today include unit pump systems, unit injector systems and common rail direct injection systems. The use of common rail is suitable for relatively high fuel injection pressure and it offers unparallel elasticity in injection strategy. For the reduction of combustion noise, NOx and soot emissions, different combination of fuel injection strategies such as pilot-main, main-post, pilot-main-post, pilot-pilot-main-post, etc. can be planned and applied in production grade engine to encounter desirable performance and emission goals.

Single cylinder engine with fuel injection pressure of 1800 bar, has high pressure, provided greater charge mixing and reduced the emissions. Further it increases the fuel injection pressures up to 2000 bar. High-pressure injection system enables the supply of finely atomized fuel to the combustion chamber and enabled to achieve better combustion processes. High fuel injection pressure allows taking full advantage of the increase of fuel flow rate. Compared to high fuel injection pressure, increased nozzle hole diameter allows a limited improvement of specific power output. This higher pressure suggestively reduced the soot emissions. Researchers have confirmed that by pre-injection of fuel, direct injection (DI) diesel engines can concurrently reduce NOx and particulate emissions on a small non-road diesel engine prototype. Different fuel injection approaches with a fixed number of multiple injections were tested for different load-speed operating points. It was identified that enhanced injection timings with multiple injection strategies are actual in reduction of particulate matter (PM), NOx, and noise levels without increasing the specific fuel consumption. Advanced the fuel injection timing significantly to encourage fuel-air mixing.

Split injection leads to enhanced utilization of the charge and allows combustion to continue later into the power stroke linked to a single injection case. This reduces the NOx level without significant increase in soot production level. By post injection, soot elements are re-burned and this reduces the soot by 20-70%. By the concept of post- injection in an optical engine to explore the cause for unburnt hydrocarbons. This study opens that post-injection reduces the HC, CO, as well as PM emissions. This was mainly due to the oxidation of unburned fuel which continued after the main injection.

Research on a DI diesel engine is appropriate to show the effect of post injection timings on the exhaust emissions. It is identified that if the post-injection is placed close enough to the main injection, the end of combustion can take place earlier compared to single injection strategy. In such conditions, NOx emissions increase due to higher temperature levels dominant during the last stage of combustion but soot and specific fuel consumption decrease due to faster combustion in the last phase.

In the present study, above mentioned advancements in common rail direct injection (CRDI) system were employed to improve the performance, emissions and combustion characteristics of a single cylinder engine by deploying and optimizing CRDI fuel injection system. Detailed inquiries of variations in engine performance, emissions and combustion characteristics with varying fuel injection timings at different engine loads were carried out.

II. SPECIFICATION OF EXPERIMENTAL ENGINE

The specification of the test engine used for the present work is given in Table I as follow

TABLE I
Specification of Engine

Working Fluid	Diesel
Number of Cylinder	1
No. of Stroke Per Cycle	4
Engine Name	Single Cylinder Diesel Engine
Bore	87.5 (mm)
Stroke	110 (mm)
Intake System	Naturally Aspirated
Metering System	Direct Injection
Compression Ratio	17.5

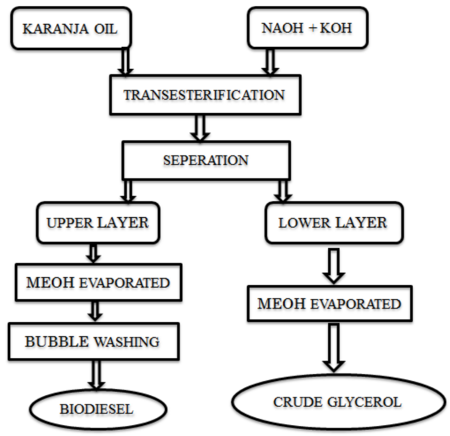
III. EXPERIMENTAL WORK

A. BIODIESEL PRODUCTION

Karanja oil is extracted from seeds of Karanja seeds. The seeds shell is removed and the oil is extracted from its kernel. The raw extracted oil from seed is greenish yellow in colour while the commercial oil available for use is light yellowish brown in colour. Its properties like density, flash point and viscosity are higher compared to diesel. The basic composition of vegetable oil is fatty acids and glycerol. The high viscosity of the vegetable oil makes it very difficult to be used as fuel in IC engine which is due to presence of triglycerides in the oil.

Fatty Acid	Structure	Formula	Weight (%)
Palmitic	16.0	$C_{16}H_{32}O_2$	11.60
Stearic	18.0	$C_{18}H_{36}O_2$	7.50
Arachidic	20.0	$C_{20}H_{40}O_2$	1.70
Oleic	18.1	$C_{18}H_{34}O_2$	51.5
Linoleic	18.2	$C_{18}H_{32}O_2$	16.0

Therefore vegetables are processed to reduce its viscosity and density. There are four ways in which oils and fats can be converted into biodiesel, namely, trans-esterification, blending, micro emulsions and pyrolysis—trans-esterification being the most commonly used method.



a) TRANSESTERIFICATION PROCESS:

The process takes place by the reaction of vegetable oil with alcohol in the presence of a catalyst. Karanja oil contains high free fatty acids (FFA) upto 20%. It requires two step processes to convert into biodiesel. The first step is acid-catalyzed esterification by using 0.5% H2SO4, alcohol 6:1 molar ratio with respect to the high FFA karanja oil to produce methyl ester by lowering and the next step is alkalicatalyzed transesterification. karanja oil was converted into its methyl ester by the transesterification process. This involves making the triglycerides karanja oil react with methyl alcohol in the presence of catalyst (NaOH) to produce glycerol and fatty acid ester. The methyl alcohol (200 ml) and 8 gram of sodium hydroxide were taken in a round bottom flask to form sodium methoxide. Then the methoxide solution was mixed with karanja oil (1000 ml). The mixture was heated to 65oC and held at that temperature with constant speed stirring for 2 hours to form the ester. Then it was allowed to cool and settle in a separating flask for 12 hours. Two layers were formed in the separating flask. The bottom layer was glycerol and upper layer was the methyl ester. After decantation of glycerol, the methyl ester was washed with distilled water to remove excess methanol. The transesterification improved the important fuel properties like specific gravity, viscosity and flash point.

B. LOW HEAT REJECTION ENGINE (LHR)

Ceramic thermal barrier coatings were originally developed and commercialized internal combustion engines applications. The prime objective which has been sought is to achieve higher thermal efficiencies by reduction of heat rejection from the combustion chamber. Several ceramic materials such as zirconium oxide, chromium oxide, aluminum oxide, and mullite have been investigated as in-cylinder engine coatings. Zirconia, thanks to its low thermal conductivity and its thermal expansion coefficient which is compatible with that of metals, has become the preferred and most studied material. Ceramic coatings can be deposited by plasma spraying. The thermal spraying technique using a plasma torch has been used most extensively for this purpose. In the plasma spray process zirconia is fed as a powder into the plasma stream of the torch where it is melted at temperatures as high as 16,000°C. The high pressure plasma gas stream propels the molten particles onto the coated surface where they solidify. Powder and process parameters are used to control the structure and properties of the coating. The thickness of coatings can range from 0.05 to 2 mm. The optimal thickness of realistic materials is usually below 0.5 mm thin coatings were reported to exhibit both better performance and durability. Besides improved thermal efficiency, advantages of ceramic coatings which have been proposed include improved engine durability, reduction in erosion and corrosion, less internal friction, lowered noise and reductions in exhaust emissions. A lot of work has been done on evaluating the effects of in-cylinder coatings on diesel engine performance and emissions. The zirconia-based ceramic coatings are used as thermal barrier coatings owing to their low conductivity and their relatively high coefficients of thermal expansion, which reduce the detrimental interfacial stresses. Applied by the Plasma spray process. At elevated temperatures, this coating forms a tenacious oxide layer that serves to protect the underlying substrate from oxidation and corrosion damage. Typically used as a bond coating in thermal barrier applications. The as sprayed condition, it provides a suitable surface for application various ceramic topcoats. This is typically used as sprayed without further finishing.

b) Coated Piston Properties:

- Base coating - Nickel Chromium
- Nominal Composition: Ni-60%, Cr-40%
- Bond coating - Yttria stabilized zirconia
- Nominal Composition: Y-9%,Zr-91%
- Physical Appearance: Dull Grey
- Typical Thickness: 250 ~ 280 Mic
- Surface Roughness: 3 ~ 4 Ra

C. EXPERIMENTAL SETUP & PROCEDURE:

The present work is carried out to study the performance and emission characteristics of a direct injection (DI) type compression ignition engine using the vegetable oil methyl esters. An Eddy current dynamometer is connected with this engine to determine the engine performance with varying load. AVL Digas analyzer and Smoke meter is used with this diesel engine to determine the emission characteristics of the engine.

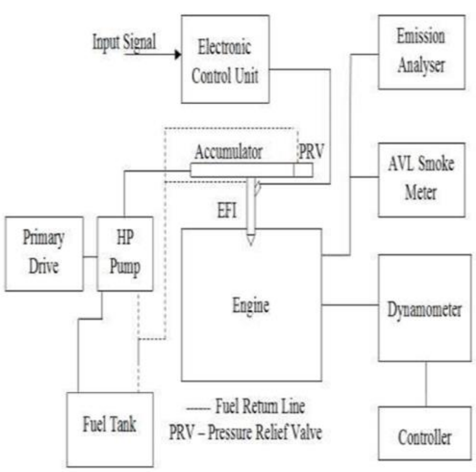
a) EXPERIMENTAL SETUP OVERVIEW:

The present work is carried out to study the performance and emission characteristics of a direct injection (DI) type compression ignition engine using the vegetable oil methyl esters. An Eddy current dynamometer is connected with this engine to determine the engine performance with varying load. AVL Digas analyzer and Smoke meter is used with this diesel engine to determine the emission characteristics of the engine. The engine fully equipped with measurements of all operating parameters. The arrangement requires

The following systems and apparatus for carrying out the desired experiment.

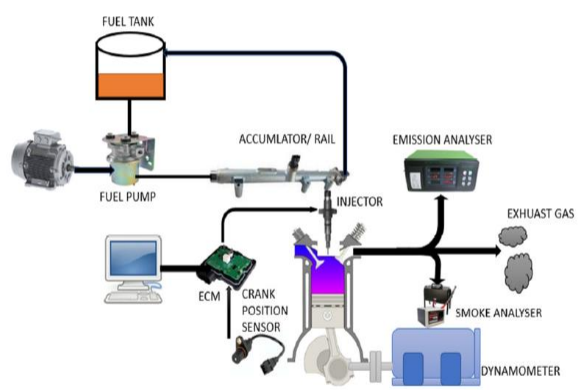
(1) Diesel engine
(2) Eddy current dynamometer
(3) Exhaust gas analyzer
(4) Smoke meter
(5) LHR coated piston

Naturally aspirated engine was selected for evaluation for two specific reasons. First, a naturally aspirated engine represents a larger population of engines sold in agricultural and construction equipment for the last 48 years. Secondly, a naturally aspirated engine is more sensitive due to longer ignition delays and lower pressure injection equipment. The Kirloskar engine is one of the widely used engines in agricultural, pump sets, farm machinery, transport-vehicles, small and medium scale commercial purposes. The engine can withstand higher pressures encountered during tests because of its rugged construction. Hence this engine is selected for the present research work. A single cylinder, water cooled, four stroke direct injection compression ignition engine with**,** compression ratio of 16.5:1, developing 3.7 kW
(5bhp) at 1500rpm was used for the present study.



The safety and working condition of instruments has to be ensured before starting the engine. The coolant flow to the eddy current dynamometer and engine has to be checked. The proper mounting of speed sensor has to be ensured to avoid vibration. Power supply dynamometer and fuel level in fuel tank should be maintained to avoid interruption during engine running condition. The fuel leak in the fuel tube should be checked and ensured for no leakage. After ensuring the safety conditions, the combustion analyzer is introduced into the cylinder head to measure pressure for every crank angle. The DAQ system has to be connected between the computer and pressure sensor to filter vibration and unwanted noise signals. The engine should be cranked very slowly to ensure working of pressure sensor, which shows a pressure rise in the interface window.

The Smoke meter should be switched on before two hours the experiment is conducted. The heater is switched ON to make the temperature above 500C. Then Smoke meter is connected to the engine exhaust manifold. The AVL Digas analyzer is switched ON and checked for leak test and the oxygen must be around 21% to ensure the proper working of emission analyzer under idle condition. The experimental work is carried out on a single cylinder, 4 stroke, direct injection CI diesel engine. The test is carried out on diesel and Karanja biodiesel blend. The engine is loaded electrically through 50kW eddy current dynamometer coupled with flywheel. The engine rpm is measured by placing sensor on other end of the dynamometer shaft. Initially the engine is tested with mechanical fuel injector which opens at pressure 200bar. The Karanja biodiesel is blended with diesel fuel in the ratio of 20% on Mass basis. The exhaust pipe is connected with the AVL smote meter which shows the smoke intensity in hatridge smoke unit (HSU). AVL Digas analyzer is used for finding the emission of HC, CO, CO_2 & NOx present in the vehicle exhaust. For each load the time for fuel consumption and corresponding emission values are recorded. The performance of engine like BTE & BSEC is calculated from the fuel consumption time. Then the spring loaded fuel injector is replaced with solenoid actuated electronic fuel injector. The low pressure line from the fuel tank is connected to the Bosch CP3 high pressure pump. The outlet from the high pressure pump is given to the common rail. The common rail is fitted with diaphragm loaded mechanical.



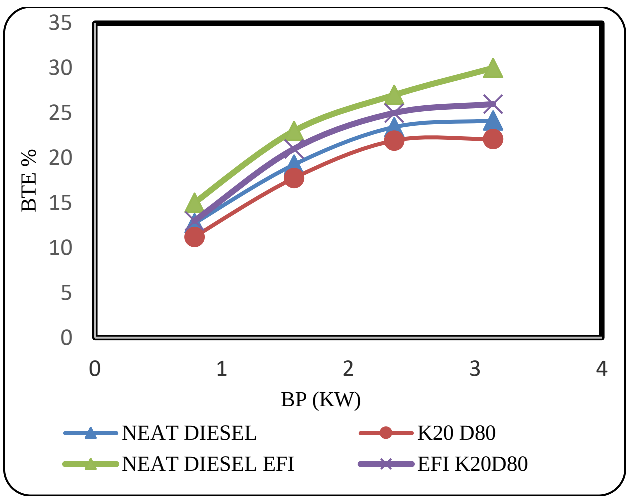
Pressure relief value. It opens the relief port when the fuel pressure exceeds 600 bar. Therefore a constant pressure of 600 bar is maintained inside in the common rail. The high pressure fuel line is connected between common rail and electronic fuel injector. The electronic fuel injector needs 12 volt to get energized. An ECU is built to energize the EFI with 12 V output supply. The required readings are noted and the comparison is made between the performance & emission characteristics. From the performance characteristics of engine with mechanical injector it is noted that BTE of biodiesel and biodiesel blends is less compared to diesel.

IV. RESULT AND DISCUSSION

A) *NON-COATED COMBUSTION CHAMBER*

Brake Thermal Efficiency:

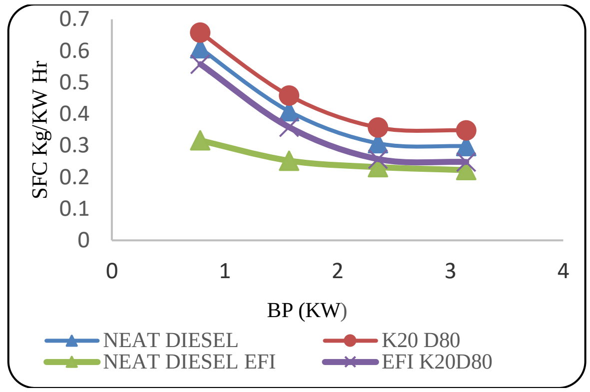
The brake thermal efficiency is the important performance parameter to decide whether the fuel can be used as alternative fuel or not. It shows the percentage of chemical energy of fuel that is converted to work. Brake thermal efficiency of diesel and Karanja oil methyl ester blends. It reveals the brake thermal efficiency of diesel is higher than biodiesel blends. The decrease in brake thermal efficiency is due to increase in density of the fuel. As its density increases the fuel droplet will have more mass compared to diesel which needs more time for complete evaporation of fuel.



Added to this reason for the drop in brake thermal efficiency is the low calorific value of the blend than diesel which decreases further as the blend increases. High load the brake thermal efficiency of neat diesel is 8.52% greater than the K20D80 biodiesel fuel, the brake thermal efficiency of neat diesel EFI is 13.33% greater than the K20D80 EFI biodiesel fuel. This clearly indicates brake thermal efficiency drops greatly when the blend increases above 20 % in volume fraction. It is observed that the decrease in thermal efficiency is due to low calorific value for pure biodiesel & its diesel blend at full load & poor atomization of biodiesel, resulting in poor combustion.

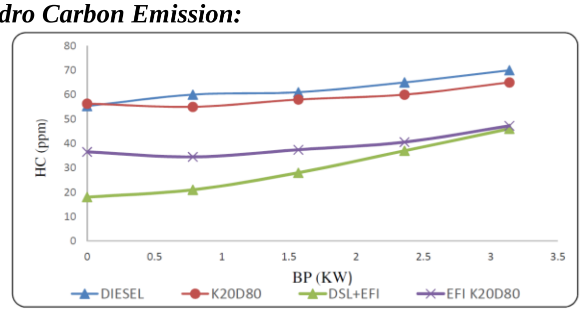
Brake Specific Fuel Consumption:

BSFC indicates the performance of engine with respect to increase in load. BSFC of diesel and biodiesel blends for various loads of an engine running at 1500 rpm. Though BSFC of biodiesel blends are higher than diesel initially the difference becomes less at higher load. The reason is high cylinder temperature and better combustion of fuel. BSFC of B20 of neat diesel K20D80 biodiesel is 14.36% higher, than the neat diesel, & the specific fuel consumption of K20D80 biodiesel EFI is 10.36% higher than the diesel EFI at high load. Though SFC of diesel is higher initially it becomes less at higher



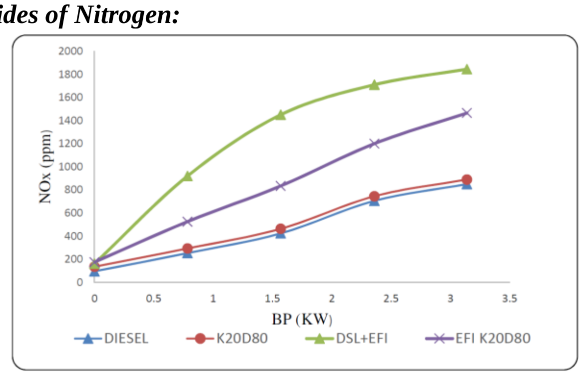
load. The reason is high cylinder temperature & better fuel combustions of fuel for K20D80 SFC is lower due to low calorific value.

Hydro Carbon Emission:



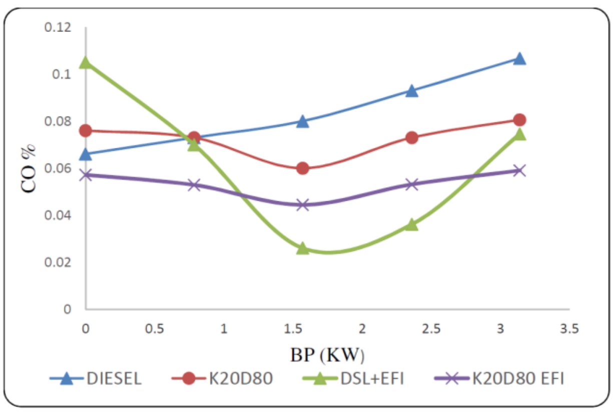
Hydrocarbon emissions of diesel (neat) is 7.14% higher than the neat K20D80 biodiesel fuel, &the hydrocarbon emission of EFI diesel is 2.12% lower than the EFI K20D80 biodiesel at high load. K20D80 are lesser compared to neat diesel. K20D80 tested in EFI results in higher HC emission than the neat diesel at increased load conditions & the quantity of fuel injection also increased. Also better fuel mixing & atomization in EFI observed. Duet to more oxygen content in Bio-Diesel, The HC emissions also reduced compared to diesel.

Oxides of Nitrogen:



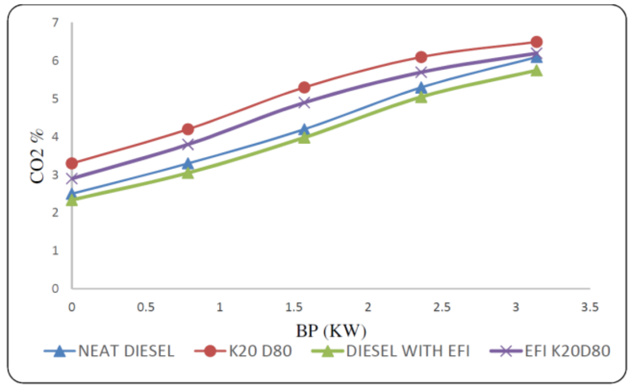
Oxides of nitrogen of K20D80 biodiesel is 4.49% higher than the diesel fuel & the Nox of EFI K20D80 biodiesel is 20.59% lesser than the EFI diesel fuel at high load. K20D80 are higher compared to neat diesel. K20D80 tested in EFI results in lesser Nox emission than the neat diesel. This mainly because of good combustion takes place. With increase in load conditions the fuel supplied increases for diesel & also in cylinder combustion also increases hence increasing Nox in diesel. Due to oxygen & high cylinder temperature in Bio-Diesel the Nox is high. Also better fuel mixing & atomization in EFI observed. The NOx emission gets higher for all blends as the cylinder temperature increases at higher load. The NOx emission of biodiesel may increase or decrease according to the type of engine used. The higher cetane number of the fuel reduces the ignition delay. Therefore the premixed combustion reduces which is the reason for higher NOx emission. The increase in diffusion combustion phase and decrease in temperature as the piston moves down too affects formation of NOx.

Carbon Monoxide:



Carbon monoxide emissions of K20D80 biodiesel is 2.61% lesser than the diesel fuel & the CO of EFI k20D80 biodiesel is 1.39% lower than the EFI diesel fuel at high load. K20D80 are lesser compared to neat diesel. it is observed that CO increases with increasing load. K20D80 tested in EFI results in higher CO emission than the neat diesel, optimum condition lower CO value compare to Neat diesel. With increasing load conditions, the quantity of fuel mixing & atomization in EFI observed. Due to oxygen & high cylinder temperature in Bio-Diesel the CO is high. CO emission increases with increase in load. The oxygen content in the biodiesel would have converted CO to CO2 resulting in less CO emission. The increase in CO may be due to increase in fuel injection for compensating increase in load to maintain the engine at constant speed of 1500rpm.

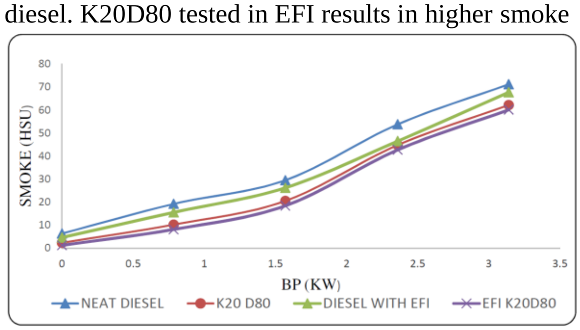
Carbon Dioxide Emission:



The oxidation of CO to CO2 in biodiesel is enhanced due to oxygen content present in the fuel. CO2emissions with respect to increase in load. CO2 emission of K20d80 is higher than diesel at no load and its difference gets reduced at high load. The reduced ignition delay resulting in prolonged diffusion combustion reduces the cylinder temperature, affects the conversion rate of CO to CO2 at higher load. The CO2 emission of K20D80 biodiesel is 6.15% higher than the diesel fuel & the CO2of EFI K20D80 biodiesel is 7.25% higher than the EFI diesel fuel at high load. CO2 emission of K20D80 is higher than diesel at higher load due to the reduced ignition delay resulting in prolonged Diffusion combustion reduces the cylinder temperature, affects the conversion rate of co to CO2 at higher load.

Smoke Emission:

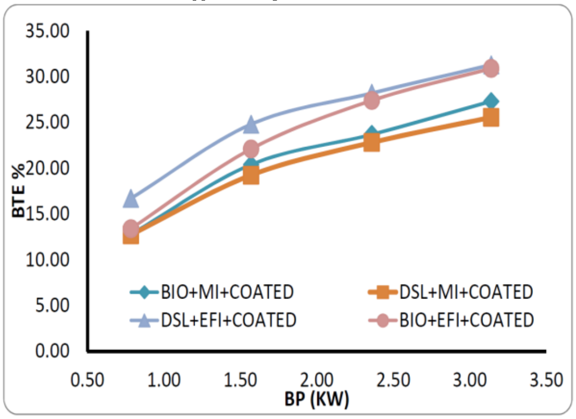
Smoke emissions of K20D80 are lesser compared to neat diesel. K20D80 tested in EFI results in higher smoke



emission than the neat diesel. With increasing load conditions, the quantity of fuel injector in increased, therefore the smoke emissions increasing. Also better fuel mixing & atomization in EFI observed. Due to more oxygen & high cylinder temperatures in Bio-Diesel the smoke is high. Due to the heterogeneous nature of diesel combustion, there is a wide distribution of fuel/ air ratios within the cylinder. Smoke emissions are attributed to either fuel/air mixtures that are too lean to auto-ignite or to support a propagating flame, or fuel/air mixtures that are too rich to ignite. Soot formation mainly takes place in the fuel rich zone at high temperature and high pressure, especially with in the core region of each fuel spray, and is caused by high temperature decomposition. If the fuel is partially oxygenated, it could reduce locally over-rich regions and limit primary smoke formation. At peak load it was observed that around 70% reduction in smoke number for pure biodiesel compared with diesel where as for B20 it's around 80%.

B) COATED COMBUSTION CHAMBER:

Brake Thermal Efficiency:



BTE at various loads of diesel and Karanja oil methyl ester blends. The increase in density of the blends increases the mass of the fuel injected inside the cylinder which results in increased time for evaporation of the fuel droplet. With increase in engine power output there is a rise in BTE for all the fuels. It is seen that K20D80 resulted in BTE in similar fashion as Diesel operation at all operating conditions. The BTE of EFI with Diesel is slightly higher than the MI with

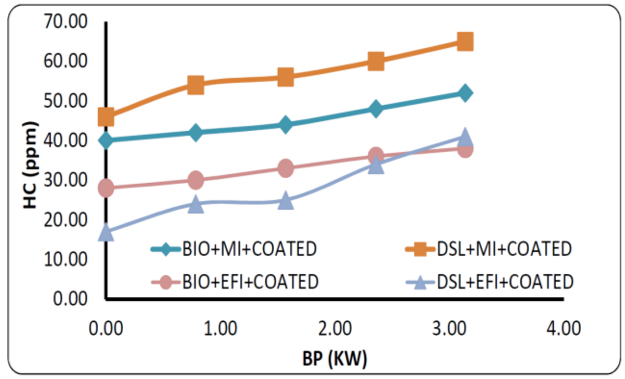
Diesel. EFI Engine with vegetable oil and showed the improvement in the performance of Brake Thermal Efficiency for entire load range when compared with

Conventional Engines. The main reason BTE increases more fuel better combustion for all cases & due to Reduction in heat loss and increase in power with increase in load. Another reason Coated with EFI will dominating good BTE is very good mixing & precise control of fuel. At peak load condition BTE of K20D80 with EFI coated engine 1.29% less as compare to diesel with EFI coated engine At peak load condition BTE of K20D80 with MI coated engine 6.85% higher as compare to diesel with MI coated engine.

Brake Specific Fuels Consumption:

The specific fuel consumption is higher for K20D80 biodiesel than diesel at constant operated conditions. This is due to complete combustion, as addition oxygen is available from fuel itself and more heat occurs in the combustion chamber due to LHR Engine. Though SFC of diesel is higher initially it becomes less at higher load due to it is inversely proportional to the thermal efficiency of the engine. The reason is high cylinder temperature & better fuel combustions of fuel for K20D80 SFC is lower due to low calorific value. Load increase, break power & thermal efficiency also increase, SFC will decrease. The control of fuel in precise in EFI, so SFC will very low. So there we minimal loses in the fuel injection At peak load condition Specific fuel consumption of K20D80 with EFI coated engine 14.81% higher as compare to diesel with EFI coated engine. At peak load condition Specific fuel consumption of K20D80 with MI coated engine 6.25% higher as compare to diesel with MI coated engine.

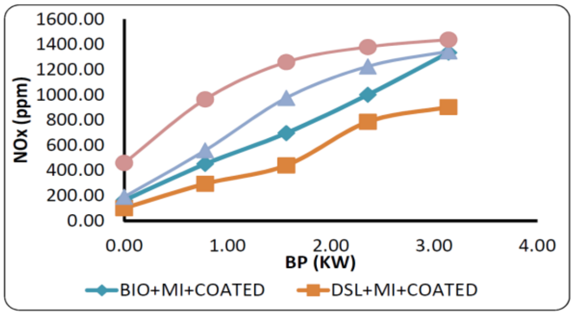
Hydro Carbon Emission:



Hydro carbon occurs to stratified combustion that takes place in the combustion chamber. The lean air fuel mixture also leads to HC emission in the tail pipe. Ignition Quality of the fuel is denoted by its cetane number. The higher cetane number of the biodiesel results in lesser ignition delay than diesel. The reduction of ignition delay indirectly indicates the activation energy needed to start the combustion is less compared to diesel. Therefore HC emission of blended fuel is lower than diesel. The high pressure increases the momentum of fuel droplet causes fuel impingent on the cylinder wall and piston head which increases HC emission as load increase. The comparison of HC emission between conventional and EFI systems for B20 blend and diesel. The hydrocarbon emission of diesel (neat) is higher than the neat K20D80 biodiesel fuel. There is inherent oxygen in Bio-diesel itself, it provides better initial ignition. So, Hydrocarbon emission was reduced. The graph shows HC increase in fuel consumption for increase in load. Due to Precise injection & proper mixing & atomization of fuel HC emissions controlled. Higher HC emission than the neat diesel at increased load conditions & the quantity of fuel injection also increased. These reductions indicate that more complete is combustion of the fuels and thus, HC level decreases significantly. At peak load condition HC emission of K20D80 with EFI coated engine 7.89% less as compare to diesel with EFI coated engine At peak load condition HC emission of K20D80 with MI coated engine 25% less as compare to diesel with MI coated engine.

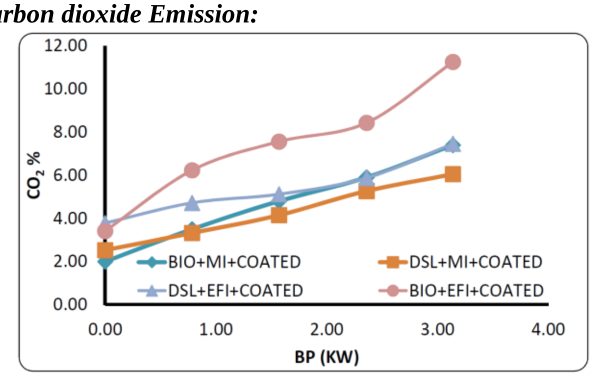
Oxides of Nitrogen:

The NOx emission gets higher for all blends as the cylinder temperature increases at higher load. The NOx emission of biodiesel may increase or decrease according to the type of engine used. The higher cetane number of the fuel reduces the ignition delay. Therefore the premixed combustion reduces which is the reason



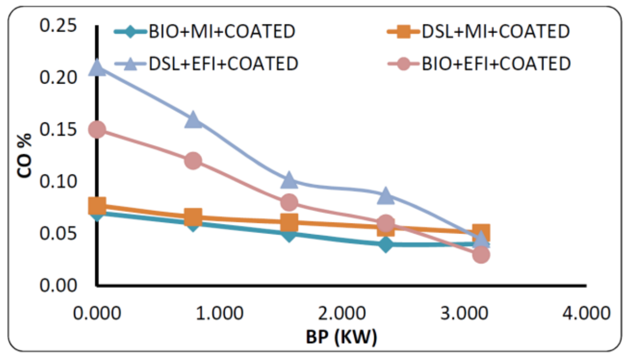
for NOx emission. The increase in diffusion combustion phase and decrease in temperature as the piston moves down affects the formation of NOx. Hence the Karanja biodiesel has less NOx emission than diesel. The comparison of NOx emission between conventional and EFI systems for diesel B20 blend. The NOx emission of EFI is higher than conventional system which is because of the high cylinder temperature. The oxides of nitrogen of K20D80 biodiesel is higher than the diesel fuel. Due to oxygen & high cylinder temperature in Bio-Diesel the Nox is high. With increase in load conditions the fuel supplied increases for diesel & also in cylinder combustion also increases hence increasing Nox in diesel. The main reason was Increase in load increase in-cylinder temperature increase in Nox The Bio diesel have high oxygenated fuel hence more Nox emission. Better mixing addition oxygen feed with lower ignition delay. But diesle doesn't have enough oxygen. As the load increases, the overall fuel-air ratio increases resulting in an increase in the average gas temperature in the combustion chamber and hence NOx formation, which is sensitive to temperature increase. At peak load condition Nox emission of K20D80 with EFI coated engine 6.83% more as compare to diesel with EFI coated engine. At peak load condition Nox emission of K20D80 with MI coated engine 47.84% more as compare to diesel with MI coated engine.

Carbon dioxide Emission:



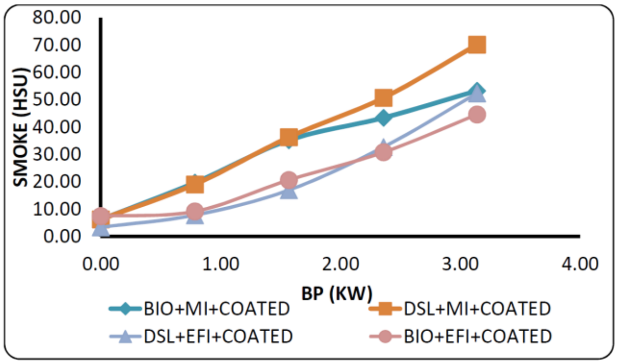
The CO2 emission of K20D80 biodiesel is higher than the diesel. CO2 emission of K20D80 is higher than diesel at higher load due to the reduced ignition delay resulting in prolonged diffusion combustion reduces the cylinder temperature, affects the conversion rate of co to CO2 at higher load. Better combustion at increasing loads gives more CO2. Since the Oxygen more in K20D80 fuel, more CO2. This is due to Better mixing & oxygen fuel. Diesel fuels have less oxygen hence less CO2 emissions. At peak load condition CO2 of K20D80 with EFI coated engine 50.80% more as compare to diesel with EFI coated engine. At peak load condition CO2 of K20D80 with MI coated engine 22.31% more as compare to diesel with MI coated engine.

Carbon Monoxide Emission:



The CO emission increases with increase in load. Blends of biodiesel give less CO emission than diesel. The oxygen content in the biodiesel would have converted CO to CO2 resulting in less CO emission. The increase in CO with respect to load is being due to increase in fuel injection for compensating increase in load. As the size of fuel droplet gets decreased the localized oxygen availability is high resulting in cylinder air utilization which reduces the CO emission. The CO emission of K20D80 biodiesel is lesser than the diesel at high load. As there is inherent oxygen in Bio-diesel itself, it converts CO into CO2. So, Carbon monoxide emission was reduced. As there is no oxygen content in Diesel, it shows higher CO emission than Bio-diesel. It is observed that CO decreases with Increasing load for diesel as well as K2080 Biodiesel. K20D80 tested in EFI results in lesser CO emission than the neat diesel. Optimum condition lower CO value compare to Neat diesel. With increasing load conditions, the quantity of fuel mixing & atomization in EFI observed. These lower CO emissions of biodiesel blends may be due to their more complete oxidation as compared to diesel At peak load condition CO of K20D80 with EFI coated engine 50% less as compare to diesel with EFI coated engine At peak load condition CO of K20D80 with MI coated engine 27.5% less as compare to diesel with MI coated engine Due to oxygen & high cylinder temperature in Bio-Diesel the CO is high. Initially, at no load condition, cylinder temperature might be too low, which increase with loading due to more fuel injected inside the cylinder. At elevated temperature, performance of the engine improved with relatively better burning of the fuel resulting in decreased CO.

Smoke Emission:



The heterogeneous combustion mixture in CI engine results in different air fuel ratio at different places inside the combustion chamber. The rich mixture is formed in the region near the nozzle and in the inner core of the droplet. Due to high temperature in absence of oxygen the fuel undergoes pyrolysis to form smoke. The sulphur content which results in PM emission is absent in biodiesel. Thus the smoke emission from the biodiesel is less compared to diesel. The advanced fuel injection system plays a major role in reducing the smoke emission in the vehicle exhaust. The reduced droplet size of injected fuel reduces the soot formation resulting in less smoke emission for EFI compared to diesel. Smoke emissions of K20D80 are lesser compared to neat diesel. This may be due to late burning in the expansion and exhaust. With increasing load conditions, the quantity of fuel injector in increased, therefore the smoke emissions increasing. Due to more oxygen & high cylinder temperatures in Bio-Diesel the smoke is high. Increased fuel concentration more smoke. Bio diesel smoke is higher due to heavier hydrocarbons. EFI used fuel less smoke observed due to better mixing. At peak load condition Smoke emission of K20D80 with EFI coated engine 17.37% lower as compare to diesel with EFI coated engine. At peak load condition Smoke emission of K20D80 with MI coated engine 31.54% lower as compare to diesel with MI coated engine.

V. CONCLUSION

Performance characteristics of the biodiesel and its blend with diesel are lower than diesel due do its lower calorific value. The blend B20 shows reasonable BTE of K20D80 with EFI coated engine 1.29% less as compare to diesel with EFI coated engine. The high pressure electronic fuel injection system shows better improvement in performance and emission characteristics of the engine considered for study. The Specific fuel consumption of K20D80 with EFI coated engine 14.81% higher as compare to diesel with EFI coated engine. HC emission of K20D80 with EFI coated engine 7.89% less as compare to diesel with EFI coated engine. Nox emission of K20D80 with EFI coated engine 6.83% more as compare to diesel with EFI coated engine. CO2 of K20D80 with EFI coated engine 50.8% more as compare to diesel with EFI coated engine. CO of K20D80 with EFI coated engine 50% less as compare to diesel with EFI coated engine. Smoke emission of K20D80 with EFI coated engine 17.37% lower as compare to diesel with EFI coated engine. From the experimental results it was clear that diesel engine operated with K20D80 Bio fuel shows better performance & emission characteristics as compare to diesel. A new electronic assisted fuel injection system for injecting fuel accurately for efficient operations. From these findings, it is concluded that K20D80 biodiesel could be safely blended with diesel up to 20% without significantly affecting the engine performance and emissions and thus could be suitable alternative fuel.

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