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Performance Analysis of Diesel Engine Using Bio-Diesels

Prof. Y. P. Gawale[1], Mr. Ejajahamad Mulla[2], Mr. Swaraj Khanvilkar[3], Mr. Giteshkumar Sonawane[4], Mr. Chaitanya Khadse[5]

Assistant Professor, Mechanical Engineering, NBNSSOE, Pune, India[1]

UG Student, Mechanical Engineering, NBNSSOE, Pune, India[2,3,4,5]

Abstract: *The energy consumption is growing or increase at an enormous rate of demand and rapid uses of alternative fuels or renewable sources of energy and environmental threat, a number of nonconventional energy sources of energy generation varieties have been studied worldwide Karanja, Neem, Palm, Waste Cooking oil-based methyl esters were produced and blended with conventional diesel. fuel blends (Diesel, B20, B40, B60, B80 and B100) were tested for their use as substitute fuel for a single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine. Test data were generated under different loads. Change in Performance and exhaust emissions (CO2, CO, HC, NOx) were also analyzed for determining the optimum test fuel at various operating conditions. The maximum increase in power is observed for Palm biodiesel and Titanium Oxide. Brake specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with increasing load. There is an increase in performance when titanium oxide is added in biodiesel blend. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel. Smoke emission reduces with blends and speeds during full load performance test.*

Keywords: Alternative Fuels or Renewable Sources of Energy, Variable Compression Ratio, Palm Biodiesel and Titanium Oxide, etc.

I. INTRODUCTION

Energy is an essential input for economic growth, social development, human welfare and improving the quality of life. Since their exploration, the fossil fuels continued as the major conventional energy source. With increasing trend of modernization and industrialization, the world energy demand is also growing at a faster rate. Apart from their indigenous production, majority of developing countries import crude oil to cope up with their increasing energy demand. Thus, a major chunk of their hard-earned export earnings is spent for purchase of petroleum products. India is also a net energy importer and almost 80% of the country's export earnings are directly spent for purchase of petroleum products.

II. LITERATURE REVIEW

G. Purna Chandra et.al [1] We get to know from the journal comparison between the performance and emission characteristics of diesel engine by using Jatropha oil and diesel which supercharger. It suggests that bio-fuel gives the higher break thermal efficiency and mechanical efficiency by using supercharger.

Apurba Layek et.al [2] Study about the engine performance having fuel as neat Jatropha diesel blend in proportion of 2:1 on volume basis. Based on the exp it concludes that ci can operate on jatropha diesel blend for term operation. The performance of the engine is identical as the Diesel engine. Jatropha diesel blend engine emits less HC and NOx.

Sovanna Pan et.al [3] Engine tests are conducted for performance and emissions using unheated Jatropha oil and preheated Jatropha oil. The baseline data were generated using mineral diesel. In this paper we considered the comparison between the B40 and B80 biodiesel and preheated biodiesel on the base line of mineral diesel. The jatropha bio diesel blend improves thermal efficiency due to additional lyricist and oxygen content. bsfc and exhaust gas temp are found to be higher which may lead to knocking effect. Co in the exhaust is less as compared with the diesel as a fuel.

Midhat Victor Fahami et.al [4] Experiment on the experimental procedure to be carried out for testing the performance of diesel fuel oil with jatropha oil. The main effect of using a biodiesel instead of ordinary diesel is appeared in the indicated power, which indicates the chemical side of the engine performance, a good chemical specification leads to a good combustion quality hence considerable efficiency compared with the ordinary petroleum fuel Source.

Amol Bharat Varandal et.al [5] The journal suggests about the performance of diesel engine with jatropha biodiesel blend. Through the experiment carried out by the author it concludes that BSFC, BTHE and EXGT of the engine are function of biodiesel blend and load on engine. For the same operating condition performance of the engine reduced with the increase in biodiesel percentage in the blend. The NOx emission is more for biodiesel blend than diesel fuel.

Experimental Setup

The setup consists of single cylinder, four strokse, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements.

III. EXPERIMENTAL METHODOLOGY

1. Check test set up for loose nut bolts, any extra items/ material lying or kept on the equipment intentionally or unintentionally to avoid accident.
2. Check engine lubricating oil for correct level, fuel in the tank and availability of water supply.
3. Open the water supply to engine cooling system, dynamometer and exhaust calorimeter. It should not be less than 300 lit/hr to engine & dynamometer and 100 lit/hr to calorimeter.
4. Put on direct fuel supply to engine.
5. Put rheostat of dynamometer to Zero position.
6. Now carefully crank the engine by opening the exhaust valve by decompression lever and on achieving sufficient speed of rotation, close the lever; eng will now start.
7. Run the engine for at least 10 min to achieve steady state (normal working temp).
8. Now load the engine by increasing the current to dynamometer by rotary switch (Rheostat) and wait for 10 mins. for steady state.
9. Put the fuel switch to measurement position and measure and record time for 10 ml fuel consumptions. Also measure and record engine speed, load on dynamometer, Manometric deflection.
10. Repeat above procedure for different blends (B20, B40, B60, B80, B100) in certain steps.
11. Reduce the load on engine gradually and shut the engine and water supply to setup.

Fuels Used in Present Work

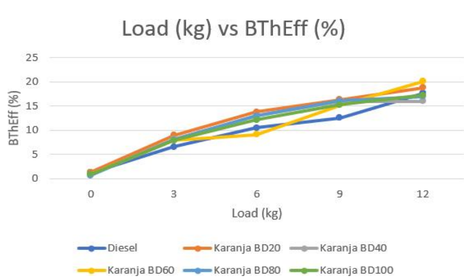
Fuels are used in the single mode of operation includes, Karanja, Neem, Palm, Waste cooking oil and its blend with diesel with Titanium oxide. Biodiesel-diesel blend was done on percent volume basis of diesel and biodiesel for net unit volume. The combinations of blends studied were very in logical manner selected i.e., biodiesel (BD)

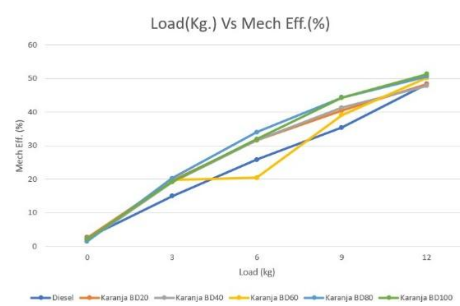
20%,40%60%,80%,100% Whereas the number signifies, percent volume of biodiesel in diesel fuel at unit volume. The properties of these fuels are given in Table, depicts visual comparison of diesel and other biodiesels.

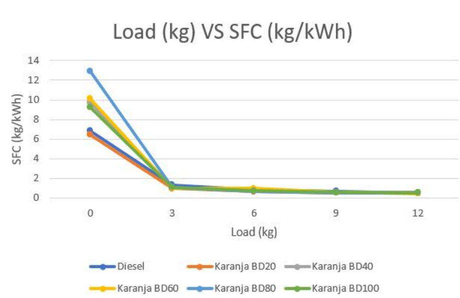
Sample	Fuel Name	Compositions
1	Karanja BD20	20 % Karanja oil bio-diesel + 80% Diesel
2	Karanja BD40	40 % Karanja oil bio-diesel + 60% Diesel
3	Karanja BD60	60 % Karanja oil bio-diesel + 40% Diesel
4	Karanja BD80	80 % Karanja oil bio-diesel + 20% Diesel
5	Karanja BD100	100 % Karanja oil bio-diesel
6	Karanja BD20 + TiO 50 ppm	20 % Karanja oil bio-diesel + 80% Diesel + TiO 50ppm
7	Karanja BD20 + TiO 100 ppm	20 % Karanja oil bio-diesel + 80% Diesel + TiO100ppm
8	Neem Oil BD20	20% Neem oil bio-diesel + 80% Diesel
9	Neem BD20 + TiO 100ppm	20% Neem oil bio-diesel + 80% Diesel + TiO 100ppm
10	Palm Oil BD20	20% Palm oil bio-diesel + 80% Diesel
11	Palm Oil BD20 + TiO 100ppm	20 % Palm oil bio-diesel + 80% Diesel + TiO100ppm
12	Waste Cooking Oil BD20	20 % Waste Cooking oil bio-diesel + 80% Diesel
13	Waste Cooking Oil BD20	20 % Waste Cooking oil bio-diesel + 80% Diesel + TiO100ppm

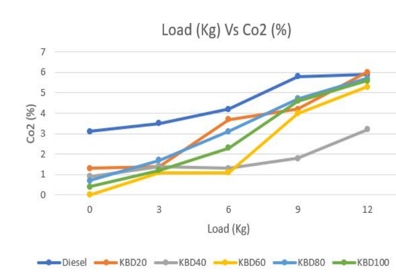
IV. RESULT AND DISCUSSION

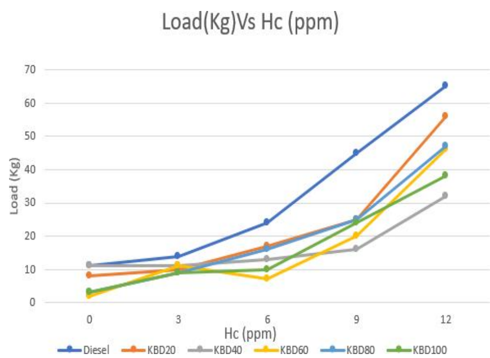
After the experimentation was carried out for each fuel at each load the performance characteristics were determined. Different graphs of Mechanical Efficiency, Brake Thermal Efficiency, Specific Fuel Consumption, Emission Characteristics were plotted against different Loads.

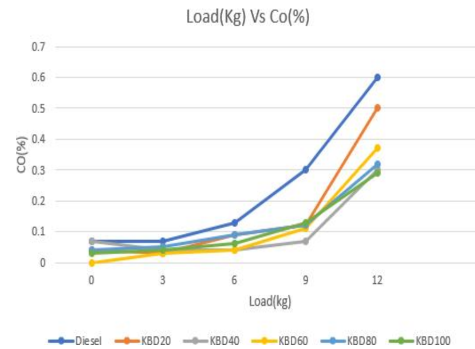


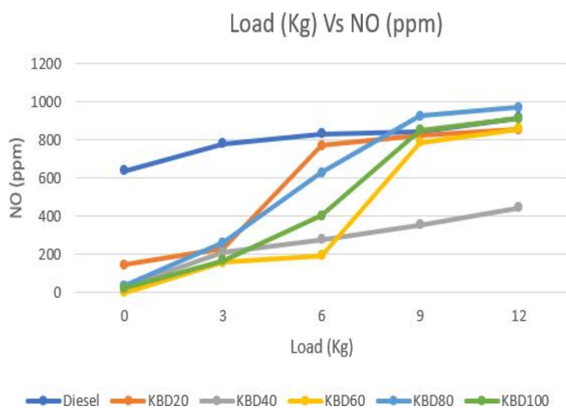












Results of Karanja Bio-diesel and its blends-

Mechanical Efficiency

it is the evident that mechanical efficiency increases with increasing load respectively. Mechanical efficiency of Karanja biodiesel blends is higher than that of the mineral diesel, as the percentage of blends increases the efficiency also tends to increase this is due to the complete combustion of fuel and brake thermal parameters.

Brake Thermal Efficiency

The BTE of different fuels is shown as a function of load. The variation in brake thermal efficiency for various blends was less than at part load than at higher load due to the raised temperatures inside the cylinder. The brake thermal efficiencies of diesel and the blends of biodiesel with diesel were seen increased with increase in load but tended to Decrease with further increase in load. The BTE of Karanja blends (BD40) were lower than with diesel throughout the entire range showing the poor combustion characteristics of methyl ester due to high viscosity and poor volatility. The BTE of BD80 is closer to that of diesel. The BTE of BD40 is found to be better.

Specific Fuel Consumption

The variation in brake specific fuel consumption with load for different fuels shows decline with increase in load. One possible explanation for this could be due to more increase in brake power with load as compared with fuel consumption. The BSFC in case of blends were higher compared to diesel in the entire load range, due to its lower heating value, greater density and hence higher bulk modulus. The higher bulk modulus results in more discharge of fuel for same displacement of the plunger in injection pump, there by resulting increase in SFC.

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Carbon Dioxide

The variation of Carbon dioxide emission with different loads. More amount of CO2 is an indication of complete combustion of fuel in the combustion chamber. It is observed that the amount of CO2 produced while using Karanja diesel blends is lower than diesel at all loads. This may be due to the late burning of fuel leading to incomplete oxidation of CO. The accrual of CO2 in the atmosphere leads to several environmental problems like ozone depletion and global warming. The CO2 emission from the combustion of bio fuel can be reverted by the plant and the carbon dioxide level and is kept constant in the temperature.

Carbon Monoxide

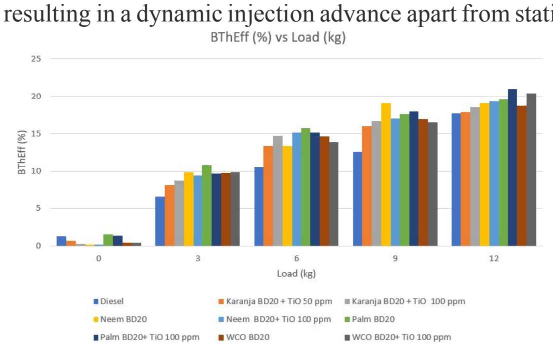
Carbon monoxide emission is mainly due to the lack of oxygen, poor air entrainment, mixture preparation and incomplete combustion during the combustion process. Carbon monoxide in the diesel emission is formed due to intermediate combustion stage. In Diesel engine which operates on the lean side of stoichiometric ratio CO emission are low. For Biodiesel operation CO emission were low compared to the diesel. The emission has decreased with increase in amount of bio diesel. In the blend the additional amount of oxygen in the bio diesel accounts for better combustion inside the cylinder and hence for reduced CO emission. At lower CR, insufficient heat of compression delays ignition and so CO emissions increase.

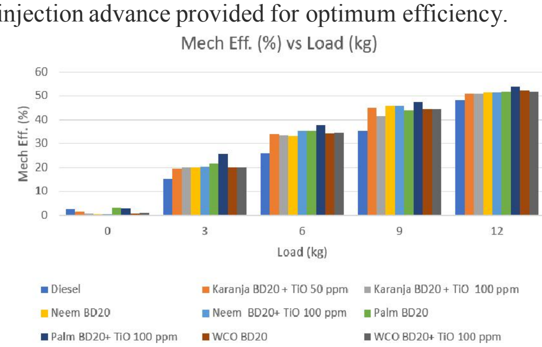
Hydro Carbons

Another emission product that is produced by the diesel engine is HC. It consists of fuel that is completely unburned or only partially burned. The amount of HC depends on the engine operating condition and fuel properties. The HC emissions were lower for biodiesel blend. HC emission in the exhaust had decreased with increasing amount of biodiesel in the blend. This may be due to the inbuilt oxygen content in its molecular structure this may be responsible for complete combustion and thus reducing the HC levels. Due to the longer ignition delay, the accumulation of fuel in the combustion chamber may cause higher Hydrocarbon Emission.

Nitrogen Oxide

The variation of NO_X emission for B20, B40, B60, B80 and B100. Compared to diesel NOx emission is higher for bio-diesel blend. The increase of NO_X emission for biodiesel operation may be due to the less intensity of premixed combustion compared to diesel. Also, NO_X emission increases with increase in blend percentage because vegetable-based fuel contains small amount of nitrogen. This contributes towards NO_X production. NO_X emissions were also higher at part loads for biodiesel. This is probably due to higher bulk modulus of biodiesel resulting in a dynamic injection advance apart from static injection advance provided for optimum efficiency.





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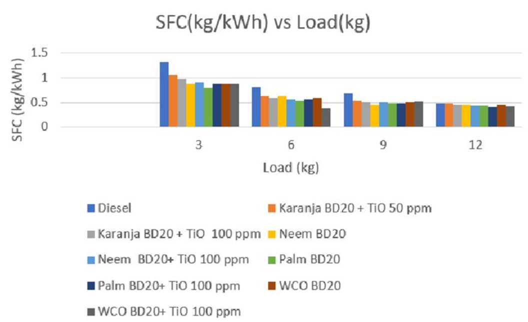

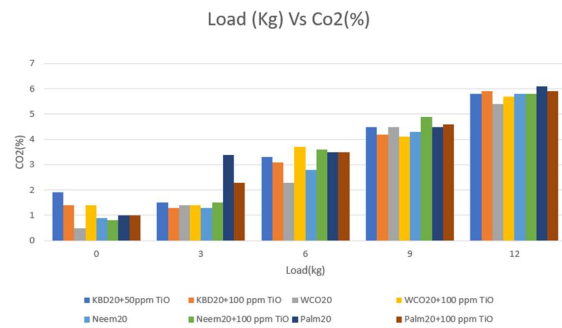

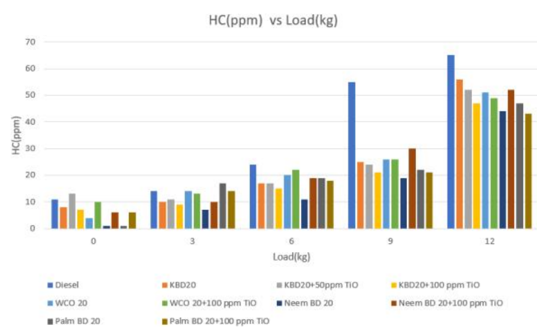

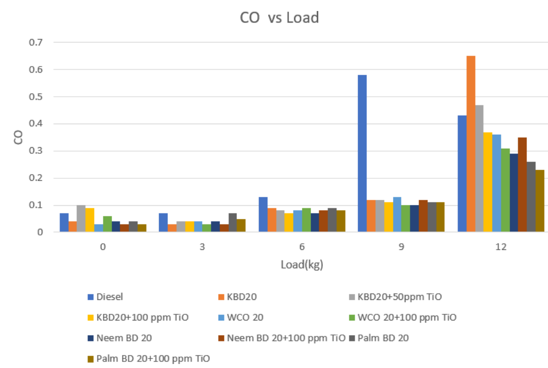

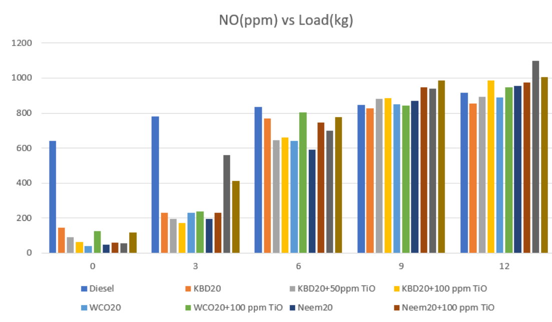

Results of Other Bio-diesels (Palm, Neem & Waste Cooking Oil Bio-Diesel)

Mechanical Efficiency

The variation of mechanical efficiency with load for diesel fuel and different biodiesel blends. It can be inferred that the mechanical efficiency of the engine increases as load increases irrespective of fuels tested. However, mechanical efficiency of the blends Palm B20 with 100ppm titanium oxide were higher than that of the diesel and other fuel blends. This can be possibly due to better lubricating property of the bio diesel which reduces frictional losses.

Brake Thermal Efficiency

SFC is not an ideal choice when comparing different fuels with different heating values. Brake thermal efficiency (BTE) is a more suitable parameter under the same operating conditions. BTE refers to the efficiency at which diesel fuel combustion is converted into effective work output. That is, the ratio of power output to energy provided by fuel. The maximum BTE of bio-diesel oil measured by under a 12kg load condition is 21%, while the BTE of diesel is the lowest. The BTE of diesel engines is often affected by ignition delay, reaction temperature, and fuel characteristics. The viscosity and density of biodiesel is high relatively, so the blends of biodiesel in the fuel will deteriorate the atomization, evaporation and air-fuel mixing effects of the fuel, resulting in uneven combustion.

Specific Fuel Consumption

Specific fuel consumption (SFC) represents the ratio of engine fuel consumption rate and brake power. SFC is usually affected by some factors such as fuel calorific value, viscosity, density and volume fuel injection system. SFC is an important indicator to evaluate the fuel economy of the engine. As we tested fuel blends containing different concentrations of Karanja, Neem, Palm and Waste Cooking Oil biodiesel at different load conditions. We found that the PalmBD20+TiO 100ppm (fuel blended with 20% palm biodiesel with 100ppm) consumes less fuel. The higher SFC of biodiesel is largely attributed to its lower calorific value, higher density and viscosity. Due to the lower calorific value, more biodiesel is needed to compensate for the lower amount of heat released.

CO2 Emission

The variation of Carbon dioxide emission with different loads. More amount of CO2 is an indication of complete combustion of fuel in the combustion chamber. It is observed that the amount of CO_2 produced while using WCOBD20 bio-diesel blends is lower than other blends at all loads. The CO2 emission from the combustion of bio fuel can be reverted by the plant and the carbon dioxide level and is kept constant in the temperature. The addition of TiO2 in the fuel blend increases the average CO2 emission values. This can be explained by the fact that nano particles improve the combustion process so that there is a balance between CO and CO2 formation when CO emission decreased, CO2 formation increased.

Carbon Monoxide

Carbon monoxide (CO) is one of the main gases emitted from vehicles. CO is formed because of incomplete oxidation of carbon in the fuel-rich zone due to an inappropriate air–fuel ratio. Generally, CO emissions are affected by fuel type, combustion chamber design, air-fuel equivalent ratio, atomization parameters, injection timing start, injection pressure, engine load and speed. Similar to HC, using biodiesel as alternative fuel can generally reduce CO emissions from internal combustion engines. As we also found that the PalmBD20+TiO has lower than CO emission than that of petroleum diesel. This is because the oxygen concentration in the combustion chamber decreased as the load increases. Although most of the studies on the emission effects of biodiesel have indicated that biodiesel can reduce CO emissions, even up to 90% in these literatures. They pointed out that the above results were mainly related to the high oxygen content and high viscosity of biodiesel.

Hydrocarbon

Hydrocarbon (HC) is usually formed when the mixture of oil and gas is too lean or too rich and the temperature in the cylinder is low. Similarly, HC is also generated due to poor atomization and corresponding wall humidity caused by the higher viscosity of biodiesel. In addition, the gap volume and the presence of flame quenching are also sources. Unburned hydrocarbons exist in the exhaust gas in the form of a complex mixture of unburned and partially burned hydrocarbons. The PalmBD20+TiO has the lower HC emission compare to other bio-diesel and diesel. This phenomenon is mainly because biodiesel tends to have more oxygen, leading to an increase in the temperature of the gas and reducing possible incomplete combustion. Biodiesel may also provide some positive factors such as post flame oxidation and higher flame speed. In addition, a higher cetane number will shorten the ID by reducing the probability of over-mixing and lean regions during the delay period, thereby reducing local fuel enrichment during combustion and reducing HC emissions.

Nitrogen Oxides

The production of NO_X emissions depends on volumetric efficiency, combustion duration, and high combustion temperature for the high energy activation required for the reactions involved. Biodiesel combustion produces higher emissions of NO_X than diesel due to its rich oxygen content, which causes the fuel-rich areas to respond to oxidation at high combustion temperatures. B20 fuel showed high NO_X emissions when contrasted with diesel. The principal reason for increasing NO_X emissions is biodiesel's molecular structure and the formation of CH radicals. However, the PalmB20+TiO blend showed fewer NO_X emissions contrasted with other blends. Metal oxide-based nanoparticles blended with biodiesel as a fuel leading to complete combustion due to these acting as oxygen donating catalysts in the combustion chamber. During the combustion phase, the nanoparticles act as catalysts that reduce nitric oxide radicals to N_2.

V. CONCLUSION AND FUTURE SCOPE

Conclusion-

- The fuel properties of biodiesel and their blends in comparison with that of diesel are comparable to those of diesel. The comparison of these properties with diesel shows that the methyl esters of Karanja, palm, Neem and Waste Cooking oil have relatively closer fuel property values to that of diesel. Hence, no hardware modifications are required for handling these fuels (biodiesel and their blends) in the existing engine.
- During full throttle engine performance test, significant change in power is not observed for all the biodiesel blends. However, slight Increase in power is observed when 100ppm titanium oxide nano particles are added.
- Specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with increased load. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel. Smoke emission reduces with blends and speeds during full throttle performance test.
- The best brake specific fuel consumption improvement is observed with PB20. Biodiesel proportion of more than 20% in the blend tends to decrease BSFC. It is seen that during part throttle test mode, blends with higher percentage of biodiesel in diesel, tends to decrease the exhaust smoke substantially. Noticeable reduction in hydro carbon (HC) and particulate matter (PM) is seen with biodiesel and their blends. However, there is a slight increase in carbon monoxide (CO), oxides of nitrogen (No_X).
- On the whole, it is concluded that the addition of 100ppm titanium oxide nano particle can be used as additive with biodiesel blends for improvement of performance and reduction in emissions except marginal increase in NO emissions.

Scope for Future Work

- 1000 hrs. durability tests may be conducted on diesel engines and the wear associated with the engine moving parts may be analyzed.
- The studies on future biodiesel and biodiesel – diesel blends fuels may be carried out in order to reduce its viscosity and No_X formation as well as improve spray characteristics of nonedible vegetable oils.

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