ANALYSIS OF PERFORMANCE AND EMISSION CHARACTERISTICS OF FOUR STROKE C.I. ENGINE USING BIO-DIESEL BLENDS

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Abstract
In the current scenario the depletion of fossil is observed because of its rapidly increasing day by day consumption. And also because of these fuels the environment today is facing a serious problems due to pollution. To avoid this it is necessary to find an alternative fuel to Diesel which should be produced from renewable resources. The fuels which are produced from these resources are termed as alternative fuels. In the present work, experimental investigations were carried out on a single cylinder 4-stroke, naturally aspirated, direct injection and water cooled CI engine with Diesel and waste vegetable biodiesel blends as fuel. From this Brake Thermal Efficiency (BTE), Brake specific fuel consumption (BSFC) and Exhaust Emissions were studied. From the experimental results it is observed that obtained Brake Thermal Efficiency is better for bio-diesel blend B20 with minimum Brake Specific Fuel Consumption. It is also observed that there is a reduction in the quantity of Carbon Monoxide and Hydro Carbon and increased exhaust gas temperature when compared with Diesel as fuel.

Key words: C.I. Engine, waste vegetable bio diesel, Diesel

I INTRODUCTION

Conventional fuels are prepared by natural processes such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. Fossil fuels contain high percentages of carbon and include petroleum, coal, and natural gas. Diesel fuel in general is any liquid fuel used in diesel engines, whose fuel ignition takes place, without any spark, as a result of compression of the inlet air mixture and then injection of fuel. (Glow plugs, grid heaters and heater blocks help achieve high temperatures for combustion during engine start up in cold weather.) Diesel engines have found broad use as a result of higher thermodynamic efficiency and thus fuel efficiency. This is particularly noted where diesel engines are run at part-load; as their air supply is not throttled as in a petrol engine, their efficiency still remains very high.

Fossil fuels are not green sources of energy. In fact, they contain high amounts of carbon and have been blamed for being the main contributor to global warming. Fossil fuels are non-renewable energy sources. This means that there is a finite amount of fossil fuels available and the reserves are not replenished naturally. This is not entirely correct, as fossil fuels are products of millions of years of natural processes such as anaerobic decomposition of organic matter. The thing is, as opposed to renewable energy sources such as wind and solar, it takes millions of years before the formation of fossil fuels takes place in any noteworthy quantities.

The second step in prioritization is the need for alternative fuels. The main reasons for customers to consider alternative fuels are raising fuel costs and pressure to reduce the environmental impacts of non-renewable fuel combustion. Sectors with high relative intensity of energy expenditure are likely to be more motivated to reduce fuel consumption or switch to alternative fuels. These sectors include aviation, road transport and rail, marine and mining.

Apart from renewability, bio-fuels are more advantageous than normal diesel in some aspects like they are having very less sulphur content and aromatic contents, higher lubricity, higher flash point, non-toxicity and higher bio-degradability. On the other side the disadvantages of bio-fuels includes very high pour point, very high viscosity, the lower cetane number, lower volatility and lower calorific value. One of the great disadvantages of bio-fuel is its highly increased viscosity, which is approximately 10-20 times greater than normal diesel fuel. More over short term tests by using bio-fuels are giving promising results but when engine has been operated for longer periods then problems are appearing, which includes more carbon deposits, injector coking with trumpet formation, piston oil ring sticking, as well as the thickness of engine lubricating oil also increases. The following methods are adopted to avoid the problems associated with their high viscosity. Micro emulsification with methanol or ethanol blending in small blend ratios with diesel fuel, cracking, preheating and conversion in to bio-fuel mainly through the transisterification process. [22–25].

The advantages of bio-diesels as fuel, apart from renewability, are the minimal sulfur and aromatic content, the higher flash point, the higher lubricity, the higher cetane number, and the higher biodegradability and non-toxicity. On the other hand, their disadvantages include the higher viscosity (though much lower than the vegetable oils one), the higher pour point, the lower calorific value and the lower volatility. Furthermore, their oxidation stability is lower, they are hygroscopic, and as solvents they may cause corrosion of components, attacking some plastic materials used for seals, hoses, paints and coatings. They show increased dilution and polymerization of engine sump oil, thus requiring more frequent oil changes. Because of all the above reasons, maximum up to 25% of bio-fuels and vegetables are generally accepted as blends with diesel fuel and can be used in existing diesel engines without modifications. Experimental studies on the CI engines with the use of bio-fuels blending with neat diesel have been reported. The present experimental work studies and compares the above bio-fuels of various origins, in blending with ordinary diesel fuel, by fuelling a single cylinder, direct injection, naturally aspirated CI engines. A companion paper extended the present investigation for hazelnut oil and its methyl esters for different blend ratios, followed by another paper dealing with their heat release and stastical analysis using insulated combustion chamber of the same engine. As mentioned above, the results of performance and emissions have been evaluated by this research work by using blends of neat diesel fuel with Waste Vagetable bio-fuel in the single-cylinder, water-cooled, direct injection, 'kirlosker' diesel engine concerning the present work. The interpretation of the experimental measurements was based on the differences of properties between the fuels tested.

Most of the experimental works reported on the use of bio-fuels in the compression ignition engines are referred to mainly single-cylinder naturally aspirated engines have been used only one or two bio-fuel oils. But the present research work steps forward in reporting on the use of two bio-fuel oils on a single-cylinder, four stroke and water-cooled diesel engine. Widely differing chemical and physical properties of bio-fuels against those of diesel fuels, are combining with the theoretical aspects of diesel engine combustion, and are used to aid the correct interpretation of the observed engine emissions and performance wise behavior.

II EXPERIMENTAL TEST SETUP

The experimental setup has been designed and fabricated in accordance with the scheme of experimentation planned to achieve the objectives formed under the research problems. The experimental techniques and testing instruments are carefully selected to minimize the errors.

A test rig was framed to analyze the performance and emission parameters of an engine. In this work it is aimed to conduct number of test runs on the developed test rig to judge the performance and emission parameters of a bio-Diesel at different operating conditions and to compare the results with normal engine operating on Diesel.

Fig: 1 Experimental test rig

The experiments are conducted in a single cylinder, water cooled, naturally aspirated, Diesel engine commonly used for transport vehicles. A rope brake dynamometer is coupled to the engine with suitable propeller shaft for balancing. The volumetric fuel metering system for fuel flow rate and air box method for measuring flow rate of inlet air and exhaust gas are arranged. The exhaust gas is used to measure the exhaust emission like HC, Co, Co_2, O_2 emission.

A system which is used for the measurement of exhaust gases consists of group of analyzers for measuring carbon monoxide (CO), oxides of nitrogen (NOx), hydrocarbons (HC), smoke density (SD), particulate and soot. The concentration of CO (in ppm) present in the exhaust gases was measured by using 'Signal' Series-7200 non-dispersive infrared analyzer (NDIR) equipped with a 'Signal' Series-2505M Cooler. 'Bosch' RTT-100 opacimeter, is used to measure the smoke level in the exhaust gas the readings of which are provided as equivalent smoke density in (mg of soot/ m3 of exhaust gases). The concentration of nitrogen oxides in ppm (parts per million, by vol.) present in the exhaust gases was measured by using 'Signal' Series-4000 chemiluminescent analyzer (CLA) that was fitted with a thermostatically controlled heated line. The total unburned hydrocarbons concentration (in ppm) present in the exhaust gases was measured with a 'Ratfish-Instruments' Series RS55 flame-ionization detector (FID) that was also fitted with a thermostatically controlled heated line.

Table: 1 Specifications of Test rig

Engine	**4 stroke Diesel engine**
No. of cylinders	Single cylinder
Cooling media	Water cooled
Rated capacity	3.5 kW @ 1500 RPM
Cylinder diameter	87.5 mm
Stroke length	110 mm
Connecting rod length	234 mm
Compression ratio	12:1-18:1
Orifice diameter	20 mm
Dynamometer	Rope brake dynamometer
Dynamometer arm length	145 mm

2.1 Experiment Methodology

The following methodology was followed to perform experiments in the present research work by using conventional fuel as well as bio-diesel blends prepared in different proportions by volume mixed with Diesel fuel. The effectiveness of the engine is analyzed in terms of break thermal efficiency; exhaust gas temperatures, break specify fuel consumption and emission of the engine are evaluated along with harmful constituents of exhaust gases such as HC, CO, CO_2.

2.2 Steps involved in the Investigation

In the investigation it is aimed to find the optimum blend based on the investigated parameters of engine.

- Initially the experimentation was performed with Diesel as fuel in the selected engine for getting baseline data for comparison.
- Preparing bio-diesel blends by mixing Diesel and waste vegetable oil bio-diesel with appropriate blend proportions like B10, B20, and B30.
- By using above three waste vegetable oil blends as fuel in the engine, experimental investigation was performed to collect required data at different engine loads and selecting one bio-diesel blend out of three blends as best bio-diesel blend by comparing its performance with remaining blends and also with baseline data obtained, this completes investigation.

2.3 Experimental Procedure

1. Before starting of engine electrical and earthling connections should be verified properly.
2. Water tank should be filled with required amount of water.
3. Fuel tank should be filled with minimum 10lit of fuel and knob should be kept in correct position.
4. Set water supply for engine around 500 l ph which is economical rate of cooling water of this engine.
5. Start electric power supply for the accessories of the engine.
6. Start the engine by operating lever during hand cracking.
7. Keep the speed constant and run the engine at that speed for 6 minutes for stabilization.
8. Repeat the procedure for loads of 4,6,8,11,13.
9. Put off the engine by operating lever.

III RESULTS AND DISCUSSION

Test engine was run with different fuels and time for 10 cc fuel consumption was calculated. Waste vegetable biodiesel showing lesser viscosity than other oils at various temperatures (Fig. 2), may be due lower density of Waste vegetable biodiesel.

3.1 Brake Thermal Efficiency

The Brake Thermal Efficiency of the engine increases with load for all the waste vegetable oil fuel blends up to three fourth loads.

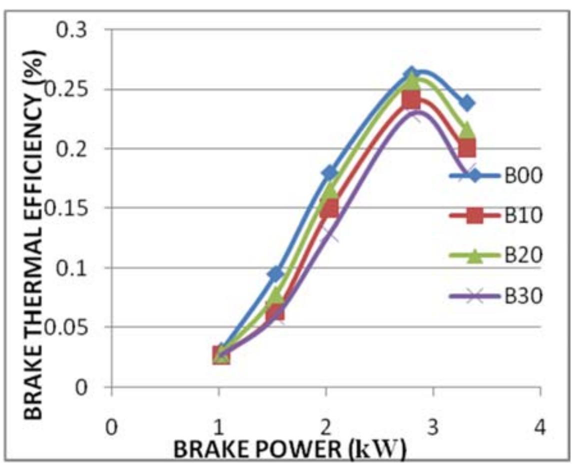

Fig: 2. Variation of Brake Thermal Efficiency

After three fourth load the thermal efficiency starts decreasing due to increase in load. It can also be observed from the figure that the thermal efficiency of the engine operated with 20% bio-diesel blend is lower than that of Diesel fuel and higher than the remaining blends.

3.2 Brake Specific Fuel Consumption

The brake specific fuel consumption with load is shown in Figure 3. It is observed from the figure that the brake specific fuel consumption of the engine increases with the increase in the percentage of bio-diesel and decreasing with increase in load. This is mainly due to the combined effects of the fuel density, viscosity and lower heating value of blends. As the percentage of bio-diesel in the blend increases, its viscosity also increases causes improper *atomization* and mixing of fuel with air leads to decreased combustion efficiency thereby increasing fuel consumption.

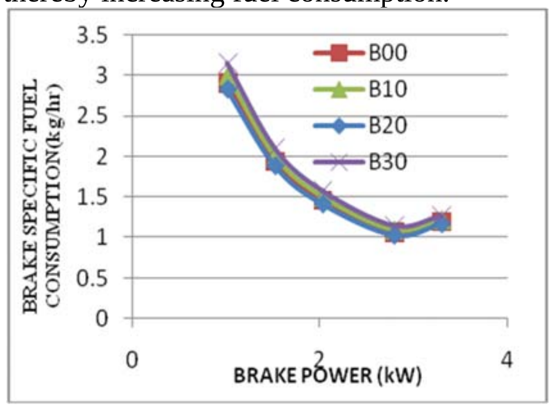

Fig: 3. Variation of Brake Specific Fuel Consumption

3.3 Unburned Hydrocarbon

The unburned hydrocarbon (HC) in the exhaust with load is shown in Figure 5.3.

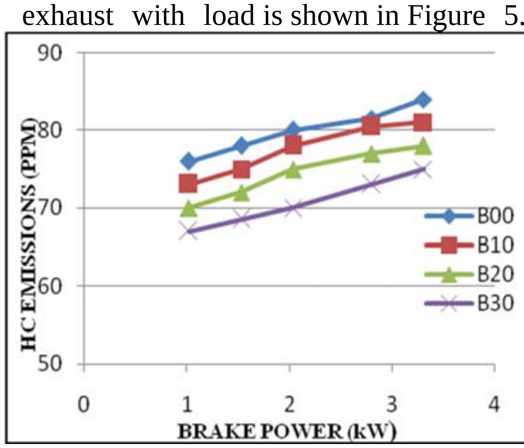

Fig: 4 Variation of Unburned Hydro Carbon Emission.

It is observed from the figure that the HC emission is decreased with the waste vegetable oil bio-diesel in the blend. The maximum reduction is observed with B30 blend followed by B20 blends .This is due to the higher percentage of oxygen associated with bio-diesel in the blend.

3.4 Carbon Monoxide Emission (CO)

The Carbon Monoxide Emission in the exhaust with load is shown in Figure 5.4. It is observed from the figure that the Carbon Monoxide Emission is decreased with the waste vegetable oil bio-diesel in the blend.

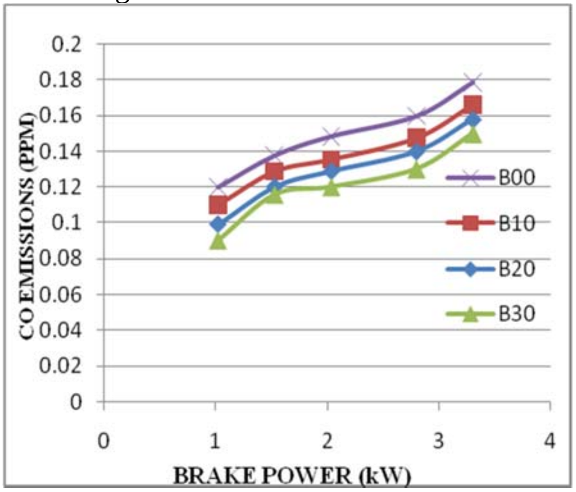

Fig: 5Variation of Carbon Monoxide Emission.

The maximum reduction is observed with B30 blend followed by B20 blends .This is due to the higher percentage of bio-diesel in the blend which increases the oxygen percentage and most of the CO converted into CO_2.

3.5 Carbon Dioxide

The carbon dioxide emission increases linearly with the load of the engine (Figure 5.5). This might be due to complete combustion at higher loads. The reduction in CO_2 emission for all the blended fuels is observed. It is also noted from the figure that when the percentage of bio-diesel in the blend increases the CO_2 emission is increased. However it is quite obvious that the CO_2 emitted from the bio-diesel is entirely different with the CO_2 emitted from the fossil fuel operation.

The CO_2 emitted by the former can be utilized for the respiration of plants. Also this CO_2 is decomposed in the atmosphere within short period of time, but the CO_2 emitted by the later is retained over several hundred years and can cause ozone layer depletion.

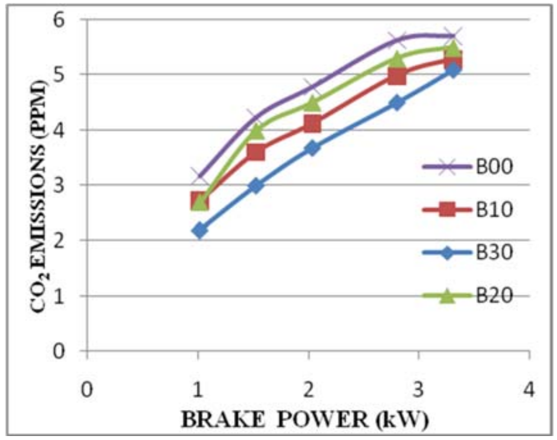

Fig: 6 Variation of Carbon Dioxide Emission.

3.6 Exhaust Gas Temperature:

Exhaust gas temperature (EGT) is varying with brake power and the results for different bio-fuel blends are presented in Figure 5.6. EGT of all the tested fuels increased with brake power. EGT of B20 is higher than that of diesel fuel at all load due to the blends' higher viscosities, which resulted in poorer atomization, poorer evaporation, and extended combustion during the exhaust stroke. When the percentage of bio-fuel is increasing its viscosity increases which results in increased EGT of the blends.

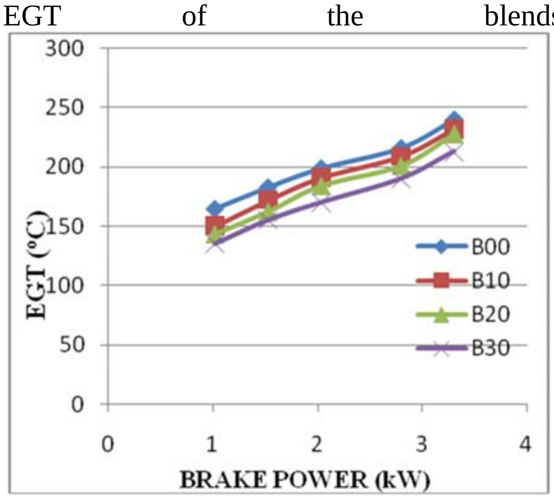

FIG: 7 Variation of Exhaust Gas Temperature

IV CONCLUSIONS

Based on the experimental results of the present work "Experimental Investigations on single cylinder DI Diesel Engine with Waste vegetable oil Bio-diesel the following conclusions are drawn.

The investigation was carried out for the evaluation of modified engine with Waste vegetable oil bio-diesel B20 as fuel based on the performance parameters and exhaust emissions. The important conclusions drawn are as follows:

- The thermal efficiency of the engine is nearer to the Diesel engine for the blend B20.
- Brake specific fuel consumption of the engine with bio-diesel blend B20 as fuel is higher when compared with conventional engine with diesel as fuel.
- The CO_2 emission is also higher for bio-diesel blend.
- The Hydrocarbon emissions of bio-diesel blend B20 is less than Diesel fuel.
- The Carbon Monoxide emissions of bio-diesel blends B20 is less than Diesel fuel.
- Blend B20 is the optimum blend for Diesel engines for better performance and emissions.
- The blend B20 is showing better performance than other blends that are tested.
- The percentage increase in BTE is 2.4%.
- The percentage decrease in BSFC is 2.08%.
- The percentage decrease in HC Emission 6.5%.
- The percentage decrease in CO Emission 9%.
- The percentage decrease in CO_2 is 2.5%.

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