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The Characteristics of a Diesel Engine Powered by Rubber Seed Oil as Bio-Diesel

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Abstract: **Diesel engines play a predominant role in various industries, from transportation to agriculture. However, they are known for emitting higher levels of nitrogen oxides (NOx) and particulate matter, which contribute significantly to air pollution and respiratory problems. Additionally, diesel engines are a major source of greenhouse gases, exacerbating climate change. One way to reduce emissions is by implementing advanced exhaust after-treatment systems, such as diesel particulate filters and selective catalytic reduction. Another approach is to use alternative fuels like biodiesel, which produce fewer pollutants. Additionally, regular maintenance and tuning of diesel engines can improve efficiency and lower emissions.**

In the Diesel engine, rubber seed oil is used very efficiently as bio diesel. Evaluations of performance and emissions were conducted. In this study, rubber seed oil was combined with diesel at different proportions, such as 10%, 20%, and 30%. A significant improvement in engine performance was observed with biodiesel. As a result, emissions were also reduced. It is more cost-effective and environmentally friendly to blend rubber seed oil with diesel than to use traditional diesel. As a result, air pollution and greenhouse gas emissions could be reduced.

Index Terms: **Diesel Engine, Rubber seed oil, Alternative fuel, Performance, Emissions.**

I. Introduction

Diesel engines [1] are most popular in trucks and buses due to their higher torque and power. However, diesel engines produce more pollutants than gasoline engines. Therefore, diesel emissions need to be monitored and controlled. There are various methods to reduce diesel emissions, such as the use of catalytic converters to minimize emissions from diesel engines. In addition, various technologies are being developed to reduce diesel engine emissions, such as hydrogen fuel cells. Diesel emissions can also be minimized using alternative fuels [2] and advanced emissions control technologies, such as exhaust gas recirculation and selective catalytic reduction. Finally, diesel engines can be optimized for performance [3] to reduce emissions [4]. This can be achieved by reducing engine speed, improving combustion, and increasing fuel efficiency. By blending vegetable oil with diesel and analyzing its viscosity at various temperatures, Rajan et al [3] reduced the viscosity of vegetable oil and used it as a fuel for a Compression Ignition (CI) engine [5,6]]. It was reported that the engine performance had improved significantly. These measures can help to reduce the number of pollutants emitted from diesel engines, making them more sustainable and environmentally friendly.

A. Transesterification

Transesterification is a chemical reaction that converts plant oils into mono-alkyl esters. In transesterification, vegetable oils with complex fatty structure molecules are treated with alcohol in the presence of catalyst to form mono alkyl esters at lower temperatures. Through transesterification, vegetable oils are reduced in viscosity by removing glycerin and excess soap from them.

B. Transesterification of crude rubber seed oil into biodiesel

An oil-to-biodiesel transesterification process was used to make biodiesel from the extracted oil samples. As a catalyst, low free fatty acid oil weight typically requires 0.30-1.5% of the total energy requirement. In order to produce fatty acid methyl esters from triglycerides, 1/5 of their weight or volume of alcohol would be required.

Methanol was added to a hydrous solution of sodium hydroxide and stirred continuously until dissolved. The container was heated to 550°C to 800°C to extract rubber seed oil (1 litre). For 1 litre of rubber seed oil, prepare a solution of methyl alcohol (200 ml) and sodium hydroxide (3.8 grams of NaOH). Monoalkyl esters are formed by removing excess glycerin and soap content. To settle the glycerin at the bottom of the container, the mixture must be left for 24 hours after preparation. The methyl esters are then transferred to the container's top side.

Additionally, the bottom glycerin is filtered separately from the methyl esters. Water or hydrogen chloride (HCl) can be used to wash the final biodiesel product. The product is warmed to remove any soap content.

Figure 1. Transesterification process setup.

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Figure 2. Rubber seed bio diesel.

Figure.1 shows the setup for transesterification and Figure.2 shows the final rubber seed biodiesel.

II. EXPERIMENTAL PROCEDURE

The experimental setup consists of an engine with electrical loading and air cooling, as well as a dynamometer with a generator. It is conducted on a naturally aspirated 4-stroke single cylinder DI diesel engine, whose specifications are shown in Table 1 and several key components are clearly indicated.

TABLE-I.
ENGINE SPECIFICATIONS

S. No	Type	Specifications
1	Engine Model	Kirloskar Engine
2	Applied Load Type	Electrical Load
3	Type of dynamometer	Coupled with generator
4	Type of cooling	Air Cooled
5	Rated Speed	1500 Rpm
6	Brake Horsepower	6.5 hp
7	Stoke Length	110 mm
8	Bore Diameter	80 mm
9	No of Cylinders	1

Figure 3. Experimental setup.

Experimental Procedure

Below is an explanation of the experimental procedure.

The engine started without load and stabilized for at least 10 minutes. The time taken for 10cc of fuel to be consumed, the ammeter readings, and the voltmeter readings were recorded according to the observation table. A 20% increase in engine load was achieved by using the engine controls, and the readings were taken accordingly. From no load to full load, step 3 was repeated. When the test is completed, the engine's load is completely relieved. Results were calculated.

On the engine, different blends were tested in the same experiment. The experimental procedure is similar to that described above. While the engine is starting, the fuel tank is filled with the appropriate proportions of fuel. It is necessary to run the engine under steady state conditions for 20 minutes prior to loading. Lastly, the engine is run at different brake power settings (200 atm) and the results are recorded.

The experiments were carried out on the Kirloskar Engine for the following fuel blends.

A. 100% diesel.
B. 10% Rubber seed biodiesel+ 90% Diesel (B10)
C. 20% Rubber seed biodiesel+ 80% Diesel (B20)
D. 30%Rubber seed biodiesel+ 70% Diesel (B30)

III. RESULTS AND DISCUSSIONS

A. Brake Thermal Efficiency(BTE)

A comparison of brake thermal efficiency between different blends of RSO (Rubber Seed Oil) and brake power is shown in Figure.4. When RSO is blended with diesel fuel, its viscosity is reduced. In terms of brake thermal efficiency, diesel, B10, B20, and B30 had maximum figures of 28.3%, 28%, 26.82, and 26.2%. When diesel is fully loaded, it is 29.92%. The result is poor atomization and vaporization of RSO fuel. B10's brake thermal efficiency is higher than all others. B10 brake thermal efficiency is 4% lower than that of diesel at full load. As a result of B10's improved viscosity and density when blended with diesel, this may be the case. The result is a better combustion process and an increase in brake thermal efficiency.

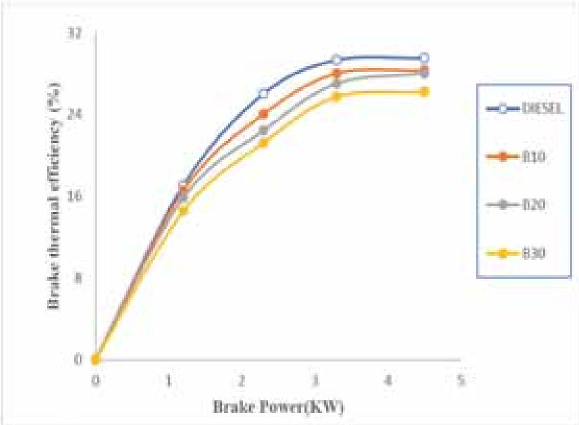

Figure 4. Variation of Brake Thermal Efficiency with BP

B. Brake Specific Energy Consumption (BSEC)

Figure.5 shows how brake specific energy consumption BSEC varies with load. At full load, the BSEC for B10, B20, and B30 is 14 MJ/kWh, 14.2 MJ/kWh, 4.8 MJ/kWh, and 4.0 MJ/kWh, respectively, while for diesel it is 13.5 MJ/kWh. At full load, B10 blend has a lower BSEC than diesel and all RSO-Diesel blends. Due to the lower viscosity and density of the blend, there is a better mixture formation, which results in improved combustion. As RSO concentration increases with diesel blend, viscosity and density increase. As a result, combustion is poor, and energy consumption is high.

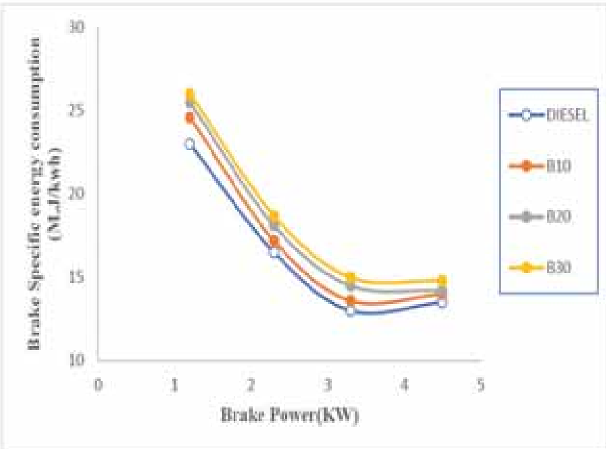

Figure 5. Variation of Brake Specific Energy with BP

C. Exhaust Gas Temperature (EGT)

In Figure.6 the exhaust gas temperature is shown as a function of brake power. EGT increases with engine loading and RSO concentrations in diesel blends. All loads result in higher exhaust gas temperatures for RSO-diesel blends than for diesel. As a result of incomplete combustion of the injected fuel and some combustion extending into the exhaust stroke, exhaust gas temperatures increase marginally with RSO-diesel blends. A neat RSO engine reaches maximum power output at 330°C, while a diesel engine reaches maximum power output at 330°C. RSO concentrations in RSO-diesel blends increase exhaust gas temperatures at all loads when RSO concentrations increase. At full load, B10, B20, and B30 exhaust gases reach 339°C, 356°C, and 378°C, respectively. With increasing engine loads, exhaust gas temperatures increased because of the slower combustion of high viscous RSO-diesel blends. This may be caused by requiring more fuel to develop the same power. At full load, the B10 blend has lower exhaust gas temperatures than all other RSO-diesel blends.

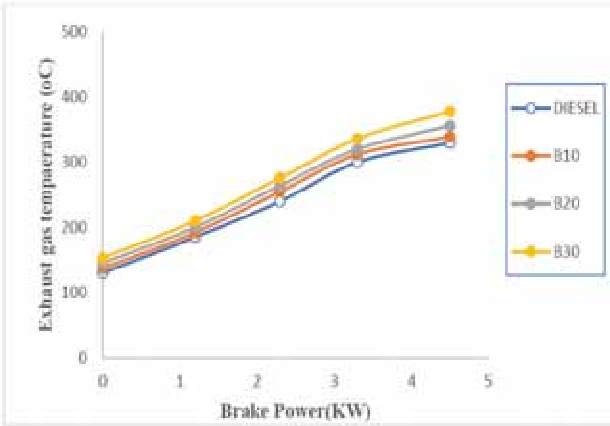

Figure 6. Variation of Exhaust Gas Temperature with BP

D. Carbon Monoxide Emission (CO)

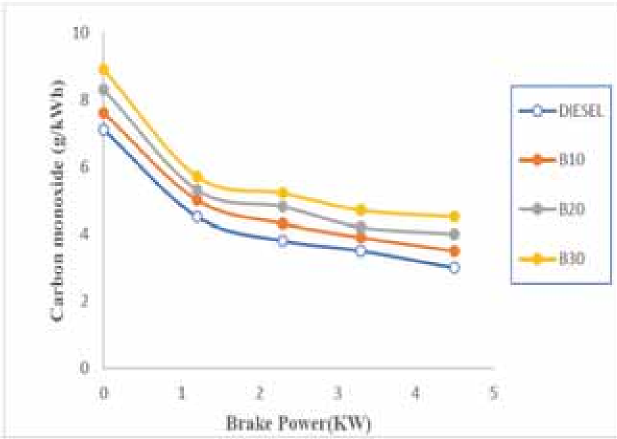

Figure 7. Variation of Carbon monoxide with BP

For all the test fuels, Figure.7 shows the variation in carbon monoxide emissions as a function of brake power. CO emissions at all loads are increased by the proportion of RSO and its diesel blends. With diesel, B10, and B30, CO emissions are 3.5g/kWh and 4.5g/kWh, respectively, while with diesel, they are 3g/kWh at full load. CO may increase due to RSO does not spraying well and is not mixed properly, resulting in poor combustion. As RSO concentration in diesel fuel increases, CO emissions increase. RSO in higher percentages in diesel blends deteriorates engine performance due to poor mixture formation. B10 blend reduces CO emissions by 70%.

E. Hydrocarbon Emission (HC)

As compared to diesel, Figure.8 illustrates how hydrocarbon emissions vary with brake power. HC emissions also increase with increasing loading and RSO percentage in the diesel blend. All RSO-diesel blends produced higher HC emissions than diesel. At full load, HC emissions for B10 and B30 are 0.61 g/kWh and 0.68 g/kWh, respectively, and for diesel are 0.58 g/kWh. The higher viscosity of RSO causes greater fuel droplets, which result in a non-uniform distribution of fuel with air, resulting in too rich pockets that can emit hydrocarbons. At all loads, HC emissions increase with an increase in RSO blending ratio. As compared to neat RSO, the B10 blend reduces HC emissions by 0.7 g/kWh at full load. As a result, the B10 blend produces a better mixture preparation and combustion.

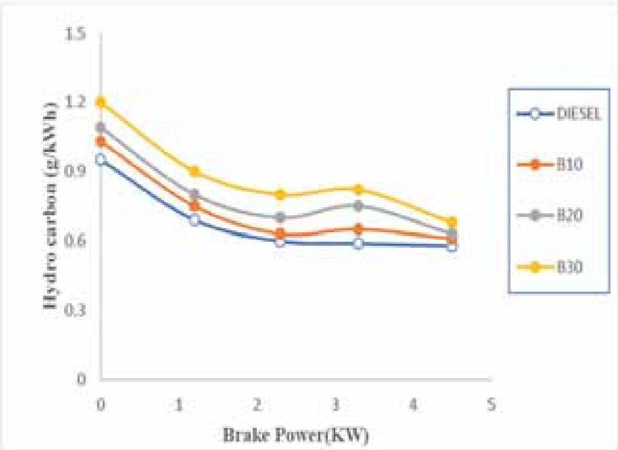

Figure 8. Variation of Hydrocarbon with BP

F. Nitrogen Oxide Emission (NO_X)

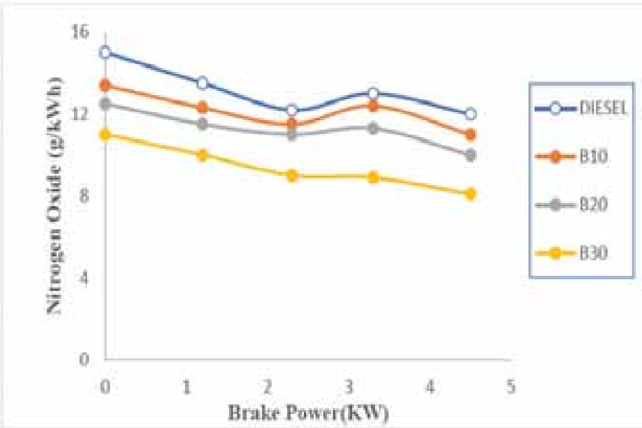

Figure 9. Variation of Nitrogen Oxide with BP

In Figure.9, NO is shown to vary with brake power for all fuels. Increasing engine load increases NO emissions because the average gas temperature in the combustion chamber increases. At full load, B10 and B30 emit 11 and 8.1 grams of NO per kWh, respectively, while diesel emits 12 grams per kWh. When RSO is used, premixed combustion intensity is reduced, which reduces NO levels. A higher RSO content in the diesel blend leads to a decrease in NO emissions. NO emissions from B10 are 3.9% lower than those from diesel fuel.

G. Smoke Opacity

Figure.10 shows the comparison between smoke with brake power for different proportions of RSO and diesel. Due to their high viscosity, vegetable oils emit considerable smoke. The smoke density at maximum power output is 4.1 BSU and 5 BSU with B10 and B30 and 3.3 BSU with diesel. It is possible that smoke density will increase due to the heavier molecular structure of RSO and its higher viscosity, resulting in poor atomization and larger droplet sizes, leading to slower combustion. Diesel fuel with a higher percentage of RSO produces more smoke. At full load, the B10 blend reduces the smoke level from 5 BSU to 4.1 BSU. The blend's viscosity is decreased, which improves combustion.

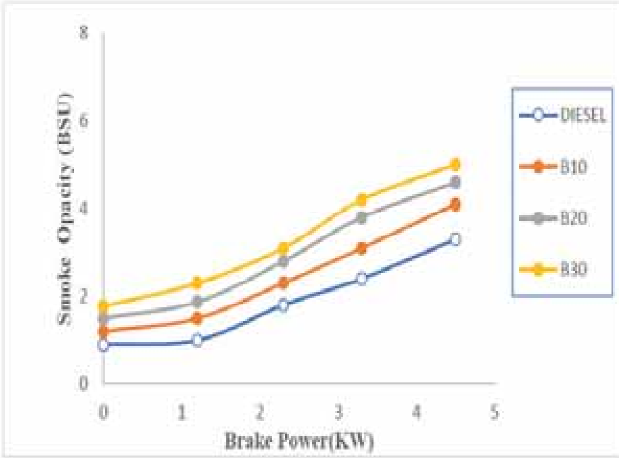

Figure 10. Variation of Smoke capacity with BP

IV. Conclusions

In the present study, rubber seed oil and its diesel blends were tested at different load conditions in a single cylinder at not varying the speed diesel engine. Following are the conclusions drawn from this experiment.

1. Optimal RSO (B10) and diesel blends result in better engine performance.
2. At full load, B10 brake thermal efficiency is 4% higher than 30% RSO.
3. As a result of the slow combustion of vegetable oil, when the diesel engine is fully loaded, exhaust gas temperatures are higher with all blends of RSO.
4. During full load, RSO emits high levels of CO and HC. B10 emits 3.5 grams of carbon dioxide per kWh and 0.61 grams per kWh at the optimum blend.
5. The optimum blend B10 operation produces NO emissions of 11g/kWh diesel at full load, which is 3.9% lower than diesel fuel.

Using Rubber Seed Oil-Diesel blend B10 as fuel without modifying it has been concluded to be the best option for compression ignition engines.

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