PERFORMANCE EVALUATION AND EMISSION CHARACTERISTICS OF BIODIESEL (METHYL ESTER) IN A CI ENGINE

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Abstract

Biodiesel is a limited diesel fuel alternative that has become popular because it can be made from a wide range of non-edible feedstocks. In these engines, the spark is caused by compression. Before biodiesel can be used reliably in business, more research is needed to figure out how it affects combustion, emissions, and how well an engine works. In this study, a direct injection 4-stroke single-cylinder diesel engine with 5% and 10% exhaust gas recirculation was used to test blends of 10% (N10) and 20% (N20) Neem oil methyl ester (NME) (EGR). Compared to diesel, N20's brake thermal efficiency (BTE) is 7.2% higher and its brake specific energy consumption is 11.4% lower (BSEC). It was shown that these two results hold true for very heavy loads. But when EGR is used, the performance indicators of the N20 mix get worse. The results of the emission analysis showed that the levels of oxides of nitrogen (NOx) went up when biodiesel was mixed in, but that these levels went down when exhaust gas recirculation (EGR) was used, and this was true for both biodiesel blends and all loading conditions. At full load, using the N20 mix instead of diesel cuts emissions of unburned hydrocarbons (UHC), carbon monoxide (CO), and smoke by 40.6%, 31.2%, and 29.6%, respectively. Even though it's still lower than diesel operation, adding EGR raised the CO, UHC, and smoke density for both N10 and N20 mixes in all loading conditions, but it's still lower than diesel operation.

Keyword: Biodiesel, Methyl Ester, CI Engine

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1. Introduction

The transportation sector is very important to the growth of any country's economy, but it always hurts the environment around it. Alternatives to fuel are a very important part of efforts to reduce pollution. More and more cars around the world are switching to fuels other than gasoline, which shows that their time has come. There are times when vegetable oils may be better than animal fats. They can be easily mixed with diesel in the neat and esterified (bio diesel) forms, are renewable, and are easy to find in rural areas. They also have a high cetane number, a rate of heat release that is similar to diesel, a low emission rate, and can be used in Compression Ignition engines with only minor changes. They are perfect for use in compression ignition motors because they have these traits. Many different types of vegetable oils, like jatrophaoil, sesame oil, coconut oil, sunflower oil, neem oil, mahua oil, peanut oil, palm oil, rubber seed oil, cotton seed oil, and rapeseed oil, have been looked into as possible fuels for internal combustion engines. Other kinds of vegetable oils are mahua oil, peanut oil, and palm oil.

Rudolf Diesel made the first diesel engine in 1900, and it ran on vegetable oil. Peanut oil was used to power the first engine. In their search for an alternative to diesel, researchers have looked at vegetable oils that humans can't eat. But it was found that there were not many of the non-edible vegetable oils that were looked into. Scientists have done a lot of tests to see how well Diesel engines that run on vegetable oils or bio-diesel work and how much pollution they put out. In particular, these studies have focused on the benefits of using either rapeseed oil or soya bean oil. Both in terms of overall performance and emissions, the biodiesel-fueled engine is better than the diesel-fueled engine. It was found that the engine's thermal efficiency had gone up, the amount of fuel used by the brakes had gone down, and the exhaust smoke had become much less cloudy. A lot of research and development is going on right now to find better ways to use vegetable oils and other alternative fuels. In place of diesel, which used to come from petroleum, vegetable oils can now be used to power diesel engines. This is the case because vegetable oils last longer than petroleum oils. During this study, bio diesel made from pongamia oil was looked at as a possible source of energy. A water-cooled, single-cylinder, four-stroke diesel engine was used to study the performance, emissions, and combustion of biodiesel blends.

Related work

Olusegun D et al.(2018) The ASTM standard procedure was used to fine-tune the fuel properties of biodiesel. Sulphur content, density, kinematic viscosity, flash, pour, and cloud points were all measured. Blends of WCO biodiesel with 0, 10, 20, and 40% AGO are called B0, B10, B20, and B100. A static immersion test was used to study the corrosion of blends on aluminium at room temperature (Al). The mechanical properties of the aluminium were looked at both before and after the corrosion test. The different styles of coupons were also looked at.

Yogesh PALANI et al.(2022) what happens to a diesel engine's performance, emissions, and how it works when different concentrations of biodiesel are used. A study that compared regular diesel to a blend of diesel and biodiesel found that the diesel-biodiesel blend had a lower rate of heat release, a shorter ignition delay, and was slightly more efficient. A study of the two fuels that was just published in a scientific journal with peer review led to these conclusions. When biodiesel blends are used, emissions like carbon monoxide, hydrocarbons, and particulate matter are cut down by a lot. The best way to fix the current fuel problem might be to mix biodiesel with other things, like alcohol. In the last part of the paper, the benefits of biodiesel and how it can be used in the future as a better alternative to diesel fuel are summed up.

Rishi Malhotra, et al.(2018) This study is mostly about how well a compression ignition (CI) engine works and how much pollution it puts out when it uses diesel fuel that has been treated with methyl ester of waste vegetable oil and diesel exhaust fluid (DEF). Biodiesel methyl ester is used in this study. It is made by mixing used sunflower oil with methanol in a process called transesterification. The transesterification process made a biodiesel methyl ester, which was then mixed with diesel at a ratio of 10:20:30, 20:80, or 30:30.

Al-Dawody et al.(2022) Experiments were done to see what happened when different amounts of spirulina algae methyl ester, a type of third-generation biodiesel, were added to diesel engines (SAME). One of three volumetric mixes are used to make standard Iraqi diesel. There are three different mixes, and each one has a different amount of SAME in it (10%, 20%, or 30%). ASTM International standards were used to figure out the properties of the fuel (ASTM). To learn more, tests were done on a single-cylinder diesel engine with different loads and compression ratios.

Ashok Kumar Yadav et al.(2016) The goal of this study was to look at the production, performance, and emissions of methyl esters made from Oleander oil, Kusum oil, and Bitter Groundnut oil in a diesel engine used for transportation. The transesterification process was used to make oleander oil methyl esters (OOME), kusum oil methyl esters (KOME), and bitter groundnut oil methyl esters (BOME) (BGOME). At a wide range of engine speeds and loads, the effects of three different methyl esters on engine performance and pollution from the exhaust were looked at.

Gugulothu,et al.(2020) To cut down on energy use and help the agricultural economy, it is important to switch from traditional fuels to alternative fuels. Because kusum oil (Schleichera oleosa) has a lot of fatty acids, the current research is focused on improving a two-step transesterification process to turn this oil into biodiesel. In line with ASTM standards, the tests use regular diesel to figure out the thermophysical properties.

2. Methodology

Transesterification

Transesterification is a metabolic process that is also called "alcoholysis." Biodiesel is made by changing the triglycerides in vegetable oils into mono alkyl esters of the same fatty acid. This is done through a chemical process. This process ends up making biodiesel.

When a fat or oil reacts with an alcohol, it makes esters and glycerin. In the transesterification process, catalysts are used to speed up the rate of reactions (Figure 1). Methanol and ethanol are two types of alcohol that are used a lot in business because they are cheap and have many useful physical and chemical properties. A molar ratio of 3 parts alcohol to 1 part water must be used to finish the transesterification reaction.

The reaction can be sped up by enzymes, alkalis, or acids, in this order: potassium hydroxide, sodium hydroxide, and sulfuric acid. In factories, alkali transesterification is used because it works better.

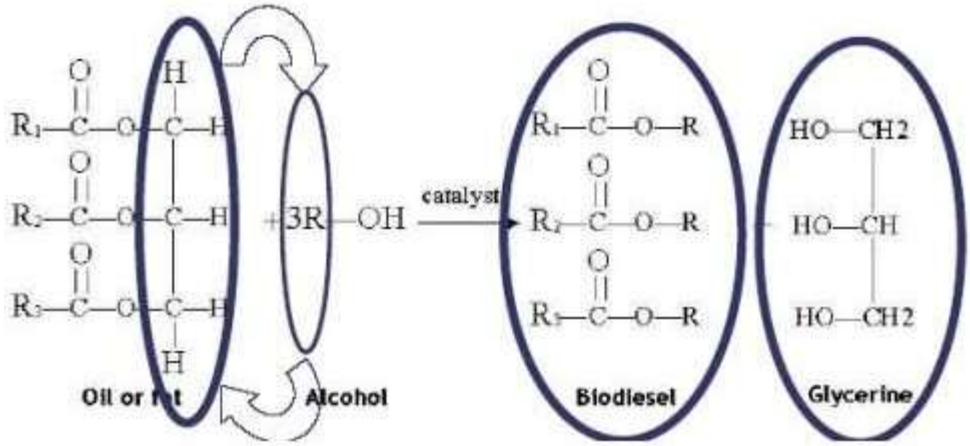

Figure 1. A process called transesterification is used to make biodiesel.

Table 1.Diesel and the methyl ester of karanja (KB) are both made of the same chemicals.

Property	Diesel	Karanja oil methyl ester
Density (kg/m^3)	850	883
Kinematic viscosity at 40°C (Cst)	2.87	4.37
Flash point (°C)	76	163
Calorific value (kJ/kg)	44000	42133

Different amounts of diesel oil were added to the mixture to make the viscosity of the transesterified karanja more like diesel fuel. The thickness of the karanja had to be lessened. Under normal conditions, the mixes that were made were often not very unstable. Table 1 shows how diesel and karanja methyl esters are similar and how they are different as fuels.

How to set up and run a test

For this study, a 4.4 kW four-stroke single-cylinder air-cooled direct-injection vertical diesel engine was hooked up to an eddy current dynamometer. The speed at which the engine turns is 1,500 rpm (Figure 2).

In Table 2, you can find all of the technical details about the car's engine. A strain gauge load cell was used to measure the engine's torque output. The load cell of the dynamometer was in that space between the stator and the base. The main pollutant from a diesel engine is the smoke it makes. An AVL smoke metre was used to find out how much smoke the diesel engine's exhaust was making. A QRO-TECH five gas analyzer was used to measure the amount of CO, HC, and NOx being released into the air. At first, diesel fuel was used to power the car's engine.

Later, methyl esters of karanja and their mixtures were used. Several rounds of testing were done on the engine's performance and emissions using non-mineral diesel fuel combinations.
Using the information in the graphs, researchers looked at the fuel economy, the amount of fuel used when stopping, and the amount of smoke produced by different fuels. Because different fuels have different calorific values and densities, brake-specific fuel consumption is not a good way to compare them.
Both diesel and biodiesel blends (from B10 to B50) were used to test the engines. As a point of comparison, the data on how well biodiesel blends worked and how much pollution they made were compared to those for diesel. With the help of different biodiesel blends and diesel, characteristic curves for CO, HC, smoke, and NOx emissions were made.

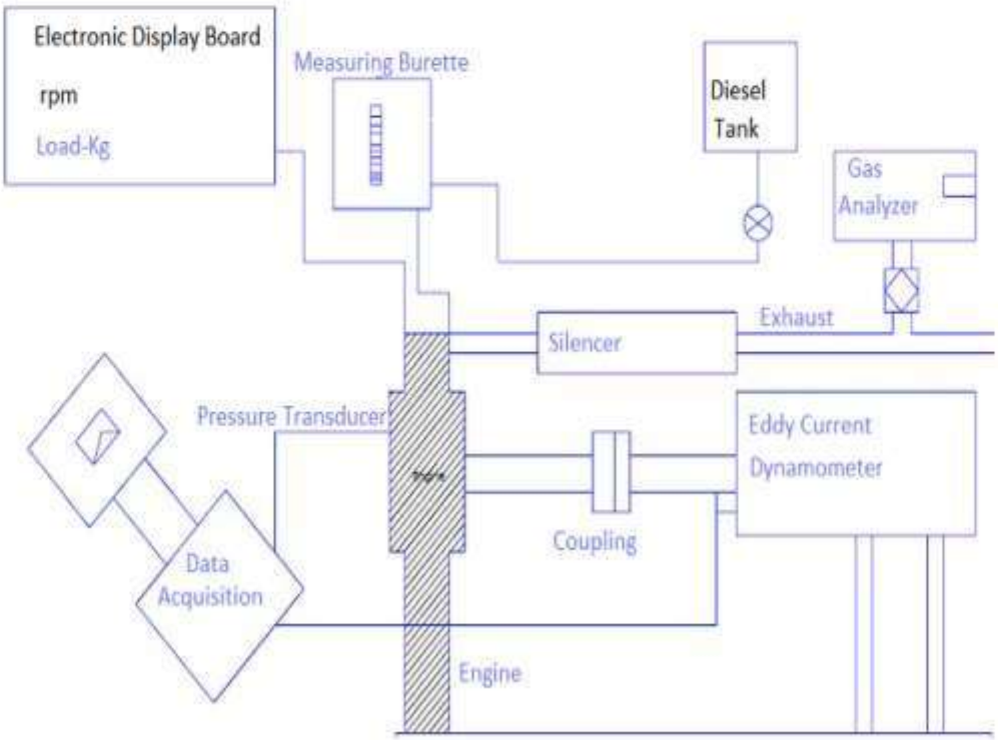

Figure 2. Setup for an experiment, shown in diagram form

Table 2.Specifications about the power plant

Model	Kirloskar TAF1
Type	Single cylinder, four stroke. Direct injection, bowl-in-piston combustion chamber
Bore and stroke	87.5 × 110 mm
Compression ratio	17.5 :1
Rated power	4.4 kW at 1500 rpm
Injector opening pressure	205 bar
Injection timing	23°bTDC
Dynamometer	Eddy current

How well brakes work in terms of temperature
One of the most important performance measures is brake thermal efficiency (BTE), which shows what percentage of the fuel's own energy is turned into work that can be used. Figure 3 compares the BTE of clean diesel to blends of 10, 20, 30, and 50% karanja and diesel. When you look at the whole load, Karanja blends had a lower BTE than diesel.

Smoke covering up

When a diesel or biodiesel blend is used and the brakes are pressed harder, the amount of smoke that comes out varies. Because biodiesel and diesel blends don't burn completely, they make much less smoke than diesel alone. This is because, unlike diesel fuel, the flame burns up all of the methyl esters when they are burned.

3. Conclusion

Based on the Performance Characteristics, the best fuel blend because its Specific Fuel Consumption (SFC) value is the lowest and its Brake Thermal Efficiency value is the highest. This is because its Specific Fuel Consumption (SFC) value is the lowest and its Brake Thermal Efficiency value is the highest (BTE). After analysing the exhaust gas emissions of each mix separately and comparing them to each other, the following conclusion was reached:

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