

EMISSION CHARACTERISTICS OF BIODIESEL DERIVED FROM USED COOKING OIL BLENDED WITH DIESEL IN THE PRESENCE OF POTASSIUM HYDROXIDE (KOH) CATALYST AS ALTERNATIVE FUEL FOR DIESEL ENGINES

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ABSTRACT

The fossil fuels usage in the world has been increasing continuously due to the energy demand, which leads to a decline in fossil fuel reserve. The increase in the cost of fossil fuels and the environmental pollution lead a search for an alternative energy. The energy should be renewable, harmless and non-polluting. Used cooking oil methyl ester is derived through transesterification process by using Used Cooking Oil (UCO) and methanol in the presence of Potassium hydroxide (KOH) catalyst. Emission characteristics have been investigated the used cooking oil and their blends with diesel. B20K and B100K reduced the carbon monoxide (CO) by 4.5% and 32.27%, hydrocarbon (HC) emission by 28.26% and 45.65%, particulate matter by 3% and 19.13% and smoke emission by 7.25% and 28.27%, respectively compared to diesel at full load. On the other hand, B20K and B100K increased the NO_x emission by 7.3% and 18%, respectively compared to diesel at the rated output. The emissions of carbon monoxide, hydrocarbon, smoke density and particulate matters were reduced and there was a slight increase in oxides of nitrogen with the used cooking oil methyl ester (UCOME), as a renewable harmless and non-polluting substitute for diesel engines.

Keywords: Used Cooking Oil, Biodiesel, Diesel Engine, Emissions, Soot, Oxides of Nitrogen.

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INTRODUCTION

Consumption of energy is increasing worldwide in various forms for a variety of purposes. The amount of consumption is directly proportional to a society's growth. Today developing countries are prospering through economic reforms and are becoming technologically advanced. The reason to find out for renewable sources has been the harmful emission reduction and increased consumption day by day and the increasing cost worldwide¹. Biodiesel can be considered a new technology, considering that all these years' consumers have had to settle for traditional diesel. Biodiesel is not harmful to the environment². A vehicle tends to pollute the environment and emits harmful gasses, whereas if the engine is using biodiesel, it emits no harmful gasses and rather keeps the environment pollution free³.

Biodiesel may not require an engine modification. Biodiesel can be blended with diesel to improve the efficiency of the engine without any hassles. Biodiesel is cheap. You can even make biodiesel in your backyard. If your engine can work with biodiesel fuel alone, then you really need not go to the gas station to buy fuel⁴. You can just manufacture some for your own personal use. Any Vehicle using Biodiesel has very low idle starting noise. It is noted that biodiesel has a Cetane number of over 100⁵.

Cetane number is used to measure the quality of the fuel's ignition. If the fuel has a high Cetane number, it can be sure that what one gets is a very easy cold starting coupled with a low idle noise. Biodiesel is cost-effective because it is produced locally⁶. A variety of fuels can be produced from biomass resources

including liquid fuels, such as bioethanol, methanol, biodiesel, and gaseous fuels, such as hydrogen and methane⁷.

The term waste cooking oil (WCO) refers to vegetable oil which has been used in food production and which is no longer viable for its intended use. WCO arises from many different sources, including domestic, commercial and industrial⁸. WCO is a potentially problematic waste stream which requires being properly managed. The disposal of WCO can be problematic when disposed of, incorrectly, down kitchen sinks, where it can quickly cause blockages in sewer pipes when the oil solidifies.

Properties of used frying oil after it gets into sewage system are conducive to corrosion of metal and concrete elements. It also affects installations in waste water treatment plants. Thus, it adds to the cost of treating effluent or pollutes waterways. Any fatty acid source may be used to prepare biodiesel. Thus, any animal or plant lipid should be a ready substrate to produce biodiesel. From this UCO, the bio diesel can be produced through transesterification process⁹.

The properties of the fuels were determined using standard methods. The study was carried out to investigate the performance, combustion and emission characteristics of used cooking oil methyl esters and their blends with diesel in varying proportions. A single cylinder, water cooled, four stroke diesel engine was used for this work. Experiments were conducted when the engine was fueled with used cooking oil methyl ester and their blends with diesel in proportions of 20:80 and 100% (by volume), which are generally called as B20K and B100K respectively. The smoke meter was used to measure the smoke density in HSU. The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency. The emission characteristics of the engine were studied in terms exhaust gas temperature, the concentration of NO_x, CO, particulate matter and smoke density.

The results obtained for UCOME, and their blends with diesel were compared with the results of diesel. Engine modification not needed if the blends proportion is around 20% Biodiesel blends with diesel. Asian regions are the potential area since the availability and have to restrict the emissions drastically in near future¹⁰.

EXPERIMENTAL

A series of samples prepared alkali catalyzed method to produce biodiesel. Methanol was blended with KOH (1 wt.% of oil) added to the reactor. The mechanism of acid catalyzed transesterification of vegetable oil (for a monoglyceride) is shown in Fig.-1. However, it can be extended to di- and triglycerides. The protonation of the carbonyl group of the ester leads to the carbocation, which after a nucleophilic attack of the alcohol produces a tetrahedral intermediate. This intermediate eliminates glycerol to form a new ester and to regenerate the catalyst. Generally, the catalyst can be used acid, alkali, and biocatalyst in transesterification method. If more water and free fatty acids are there in triglycerides, the acid catalyst can be used. Table-1 shows the properties of various blends prepared through the transesterification process.

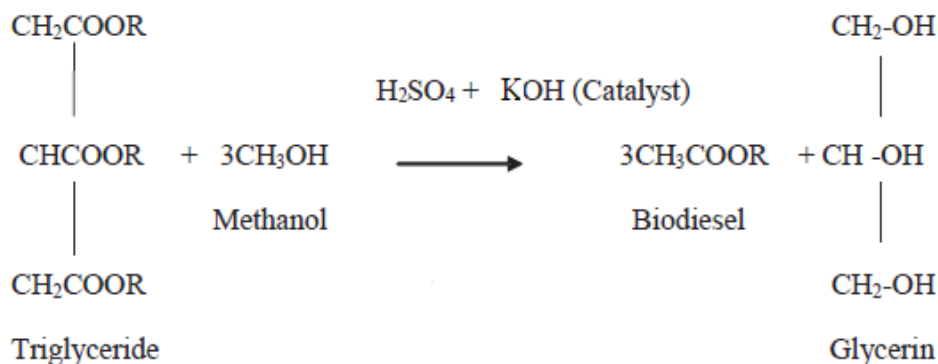


Fig. -1: Transesterification Process¹¹

The performance tests were carried on a single cylinder, four strokes, and naturally aspirated and water-cooled Kirloskar computerized diesel engine test rig. This computerized test rig was used for reading the test parameters. The experiment covered a range of loads (0%, 25%, 50%, 75% and 100%).

Table-1: Properties of Various Blends

Fuel	Fuel Density (kg/m ³)	Calorific Value (kJ/kg)
Diesel	830	42000
B20K	884	41392
B100K	914	37848

RESULTS AND DISCUSSION

Carbon Monoxide Emissions

From the Fig.-2, it can be observed that there is significant CO reduction for tested biofuels at all loading conditions compared with diesel.

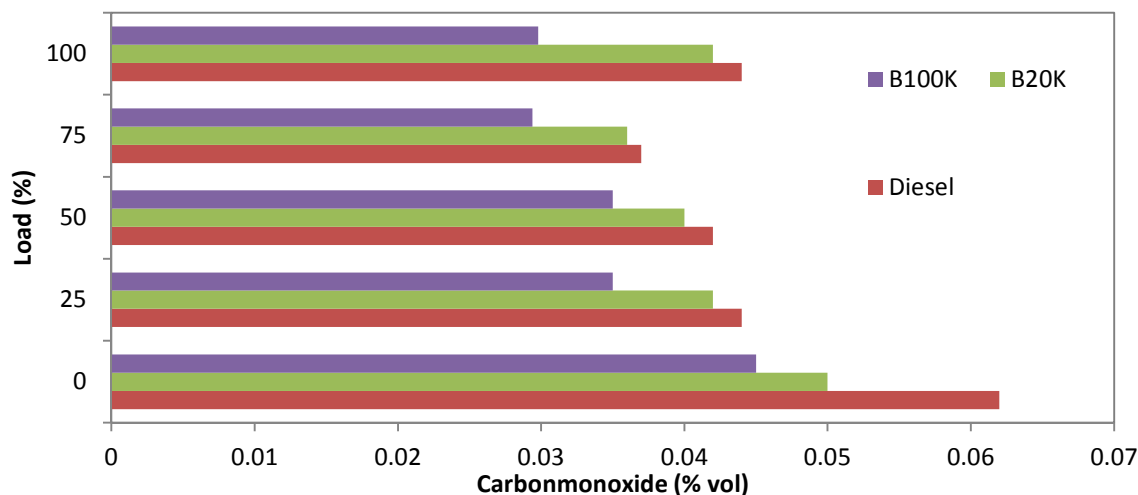


Fig.-2: Carbon monoxide (% Vol) Vs Load (%)

Compared with diesel fuel the biodiesel blends shows lower carbon monoxide emission because of low viscosity and good spray characteristic of biodiesel blends. Complete combustion of fuel due to higher availability of oxygen results in lower carbon monoxide¹². At engine full load, results show lower CO levels when running 100% biodiesel relative to the 20% biodiesel and neat diesel. The lower CO of 0.0298 % vol. was obtained, when the B100K fuel was tested, 0.042 % vol, when B20K has tested and 0.044 % vol, when diesel fuel was tested at full load conditions.

Unburned Hydrocarbon Emissions

The Unburned hydrocarbons emissions measured for test engine as a function of engine load and biodiesel blending ratio are shown in Fig.-3.

UHC not depends on engine load so the variation is about 5 to 10% only in the case of unburnt hydrocarbon. Improper mixed is another reason for the UHC emission, for the specific engine, the mixing degree depends mainly on the engine speed¹³. The UHC is increased due to low oxidation rate at low temperature or it may be due to low oxygen contents¹⁴. The used cooking oil having oxygen atoms in its structure enhance the oxidation of fuel elements and so UHC emissions are reduced. The lower HC of 25 ppm was obtained, when the B100K fuel was tested, 33 ppm when B20K was tested and 46 ppm when diesel was tested at full load conditions.

Oxides of Nitrogen

The variation of NO_x emission with various ratios of used cooking oil biodiesel is shown in Fig.-4. It is observed that the NO_x emission is increasing trend than that of diesel. NO_x emission is higher by at full load condition¹⁵. The reason for higher NO_x emission could be due to higher peak flame temperature¹⁶.

The lower NO_x of 1200 ppm was obtained, when the diesel fuel was tested, 1352 ppm when B20K was tested and 1541 ppm when B100K was tested at full load conditions¹⁷.

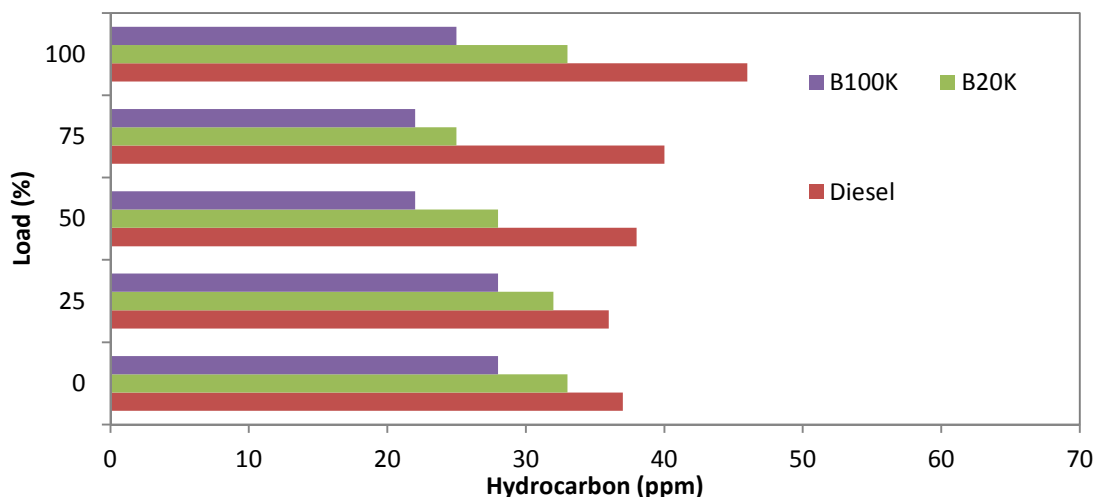


Fig.-3: Hydrocarbon (ppm) Vs Load (%)

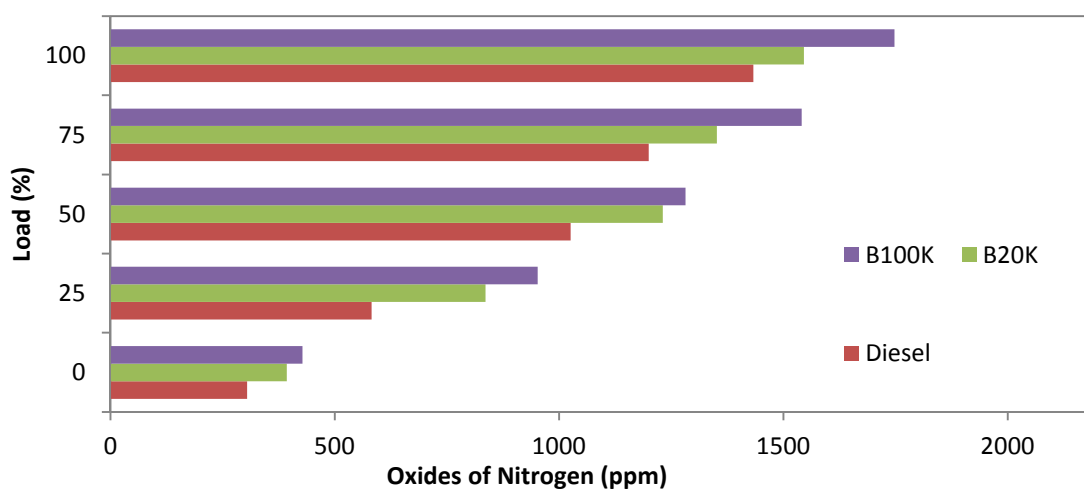


Fig. -4: Oxides of Nitrogen (ppm) Vs Load (%)

Smoke Density

Particulate matter emissions are due to the incomplete combustion in the burning process. Due to the availability of oxygen in the biodiesel complete combustion takes place in the cylinder. Particulate matters are higher for diesel than the other fuels used for the testing. When the blends are increased the particulate matter is reduced¹⁸. The lowest particulate emission of 0.51 g/min was obtained from B100K fuel as shown in Fig.-5.

Smoke density is higher in diesel than all other biodiesel blends. The smoke density of BK blends are compared with diesel are shown in Fig.-6. When the blends are increased in percentage, the smoke density is reduced. The lower smoke density of 18.8 HSU was obtained, when the fuel B100K was tested at full load conditions. Since BK and its blends are oxygenated fuels, they endorse better combustion and the outcome is in the reduction of smoke density^{19,20}.

CONCLUSION

The biodiesel can be produced from used cooking oil to reduce environmental pollution. The emission characteristics of this biodiesel derived through transesterification process by using used cooking oil

(UCO) and methanol in the presence of Potassium hydroxide (KOH) catalyst shows favorable emission reduction as reported below:

1. The carbon monoxide emission was reduced by 4.5% with B20K biodiesel and 32.27% with B100K fuel.
2. The hydrocarbon emission was reduced by 28.26% with B20K biodiesel and 45.65% with B100K fuel.
3. The Oxides of nitrogen emission was increased by 7.3% with B20K biodiesel and 18% with B100K fuel.
4. The particulate matter was reduced by 3% with B20K biodiesel and 19.13% with B100K fuel.
5. The smoke density was reduced by 7.2% with B20K biodiesel and 28.27% with B100K fuel.

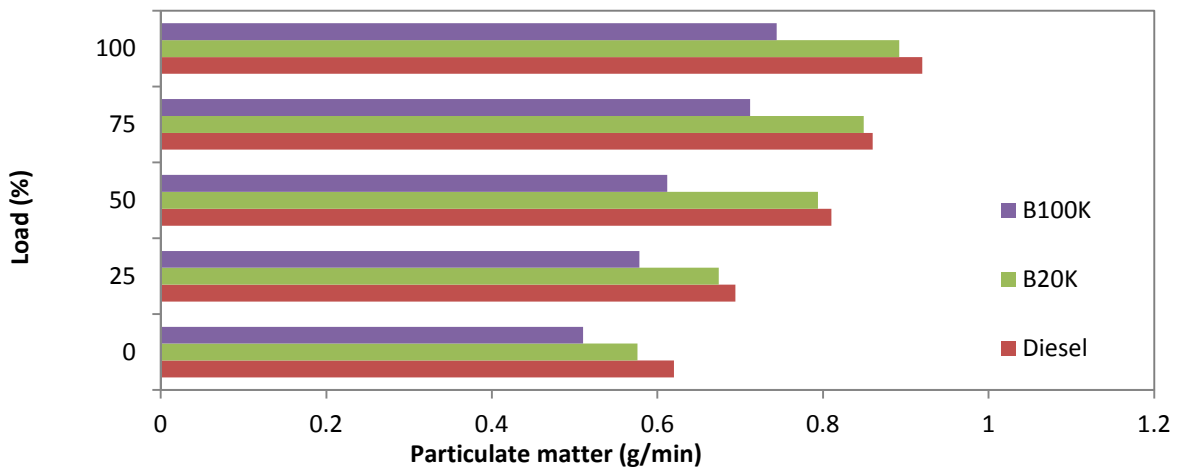


Fig.-5: Particulate matter (g/min) Vs Load (%)

It is concluded that used cooking oil methyl esters and their blends can be directly used in a diesel engine without any engine modifications. Compared to all fuels, the B20 blends gives all the results almost closer to diesel, the B20K is better because B20K has better calorific value and density, which are closer to diesel.

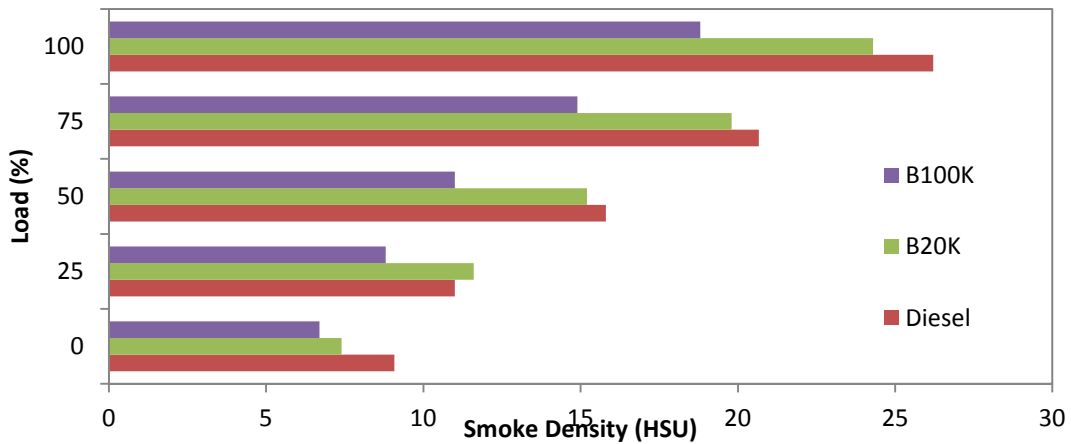


Fig.-6: Smoke Density (HSU) Vs Load (%)

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