EMISSION CHARACTERISTICS OF TROUT OIL BIODISEL-DIESEL FUEL BLENDS IN AN IDI COMPRESSION IGNITION ENGINE

ИЗСЛЕДВАНЕ ЕМИСИИТЕ НА ДИЗЕЛОВ ДВИГАТЕЛ С РАЗДЕЛЕНА ГОРИВНА КАМЕРА ПРИ РАБОТА СЪС СМЕС ОТ РИБЕНО БИОГОРИВО И ДИЗЕЛ

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Abstract: The increasing industrialization and motorization of the world has led to a steep rise for the demand of petroleum- based fuels. Petroleum-based fuels are obtained from limited reserves. These finite reserves are highly concentrated in certain regions of the world. Hence, it is necessary to look for alternative fuels which can be produced from resources available orally within the country such as alcohol, biodiesel, vegetable and animal fat oils etc. In this study, usability of trout oil biodiesel–diesel fuel blends as an alternative fuel for diesel engines were studied. Biodiesel was produced by reacting trout oil with methyl alcohol determined at optimum condition. The trout oil biodiesel–diesel fuel blends were tested in a single cylinder indirect injection (IDI) diesel engine. Engine exhaust emission values were measured at different load condition. It was seen that CO emissions decreased to approximately 27% and HC emissions decreased to 42% with the blended fuel B50 but NO_x emissions increased up to with the all new fuel blends. These results were compared with diesel fuel values.

KEYWORDS: BIOFUELS, EXHAUST EMISSION, TROUT-OIL BIODIESEL

1. Introduction

Transportation and agricultural sector is one of the major consumers of fossil fuels and biggest contributor to environmental pollution, which can be reduced by replacing mineral-based fuels by bio origin renewable fuels. There are a variety of bio fuels potentially available, but the main bio fuels being considered globally are biodiesel and bio ethanol [1]. Bio-ethanol can be produced from a number of crops including sugarcane, corn (maze), wheat and sugar beet. The last two are currently the main sources of ethanol in Europe [2]. Biodiesel is the fuel that can be produced from straight vegetable oils, edible and non-edible, recycled waste vegetable oils, and animal fat [3–4]. Europe has committed to promotion of the use of bio fuels or other renewable fuels as a substitute for gasoline or diesel in the transport sector [1]. It requires EU member states to set indicative targets for bio fuel sales and the reference values are 2% bio fuel penetration in gasoline and diesel by 2005, raising it to 5.75% by 2010[1]. There are several factors that need to be taken care before recommending any alternative fuel to be used in existing technologies on a large scale. These factors are stated below. Extent of modifications required in the existing hardware, i.e., if any alternative fuel needs extensive modification in the existing hardware involving huge capital then it may be difficult to implement. Investment costs for developing infrastructure for processing these alternative fuels. Excessive infrastructure cost may act as a constraint for the development of the energy resource. Environmental compatibility compared to conventional fuels. If the new fuel is more polluting then it will be unacceptable as fuel. Additional cost to the user in terms of routine maintenance, equipment wear and lubricating oil life. Excessive additional cost will have an adverse effect on the widespread acceptance of this fuel[1]. Nowadays, to produce biodiesel fuel, transesterification is the current method which is used efficiently. The transesterification process involves the reaction of alcohol with the oil to release three "ester chains" from the glycerin backbone of each triglyceride. The reaction requires heat and a strong base catalyst to achieve complete conversion of the vegetable or animal fat oil into the separated esters and glycerin. The transformation of sunflower oil by transesterification to produce biodiesel has been studied and the results showed that the biodiesel was an excellent substitute for fossil fuels under optimum conditions [11]. Zhang et al. [5], investigated the combustion characteristics of turbocharged direct injection diesel engine using blends of methyl, isopropyl and winterized methyl ester of soybean oil with diesel as a fuel. They found that all fuel blends except isopropyl ester had similar combustion behavior. Ignition delay for ester/diesel blend was shorter than diesel as a fuel. Senatore et al. [6] found that with rapeseed oil methyl ester heat release always takes place in advance as compared to diesel and injection also starts earlier in case of biodiesel as a fuel and average cylinder gas temperature was higher in case of biodiesel as a fuel. McDonald et al. [7] investigated soybean oil methyl ester as a fuel on a caterpillar indirect injection diesel engine and found that overall combustion characteristics were quite similar as for diesel except shorter ignition delay for soybean methyl ester. Kumar et al. [8] found that for Jatropha oil methyl ester, ignition delay was higher as compared to ignition delay for diesel as a fuel on a constant speed diesel engine. Selim et al. [9] tested jojoba oil methyl ester (JME) as a fuel on Ricardo compression swirl diesel engine and found that the pressures and pressure rise rates for JME are almost similar to that as gas oil. JME, however, exhibits slightly lower pressure rise rate than gas oil, and JME seems to have slightly delayed combustion. Experimental investigations have been carried out by Sinha and Agarwal [10] to examine the combustion characteristics in a direct injection transportation diesel engine running with diesel, biodiesel (rice bran oil methyl ester) blend. A Mahindra & Mahindra make four cylinder direct injection diesel engine was instrumented for measurement of combustion pressure, rate of pressure rise and other in-cylinder parameters such as rate of instantaneous heat release, cumulative heat release rate, mass fraction burned etc. Tests were performed at different loads ranging from no load to 100% rated load, at constant engine speed. A careful analysis of heat release and other combustion parameters has been done, which gives precise information about the combustion process, when using bio diesel.

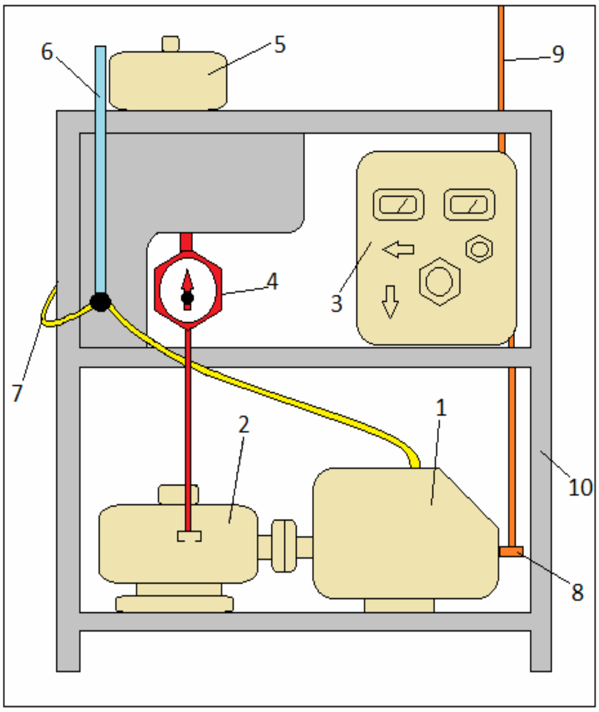
In this experimental study, a single cylinder, in direct injection diesel engine was used. Trout oil methyl ester and diesel fuel were tested at different load condition. Exhaust emission characteristics were investigated.

2. Experimental setup and method

2.1. Installation of test engine

In this study, Lister Petter Engine that is a single-cylinder research engine was used. Combustion products and unburned hydrocarbon behaviors in the exhaust line were investigated experimentally

System set-up was installed. The schematic layout of the test engine bench is given Fig.1.



1.Single cylinder diesel engine	2.Electrical dynamometer
3.Control panel of the bench	4. Torque measurement Instrument.
5.Fuel tank	6. Fuel Consumption. Measurement. Inst.

Figure.1 Schematic layout of the test engine bench

Diesel-biodiesel blends were prepared at Gazi University Chemical Engineering Laboratory. All tests were investigated at Gazi University Internal Combustion and Automotive Laboratory. After the calibration of the measurement devices, exhaust analysis instrument was mounted the test bench. To measure the exhaust temperature and to collect the data, Elimko logger was used. Pure diesel and biodiesel-diesel blends properties are shown in Table.1

Table.1 Properties of pure diesel and diesel-biodiesel blends.

Fuel Blend Type	*Diesel*	*B20*	*B40*	*B50*
Sulphur content %	*0,05*	*0,01*	*0,02*	*0,03*
Calorific value mj/kg	*39,756*	*41,56*	*40,62*	*40,15*
Flash Energy kj/mol	*12,00*	*20,00*	*18,00*	*17,00*
Cetane number	*51,30*	*48,66*	*49,32*	*49,65*
Density at 323 K (kg/m3)	*835,00*	*841,00*	*852,00*	*857,50*
C	*0,773*	*0,8506*	*0,8312*	*0,8215*
H	*0,118*	*0,1244*	*0,1228*	*0,122*
O	*0,108*	*0,0248*	*0,0456*	*0,056*

2.2. Experimental methods

For this experimental study, a single cylinder, in-direct injection diesel engine was used. The engine characteristics are shown in Table 2. Blends of trout oil methyl ester and diesel fuel were tested at different load condition when engine speed was constant at maximum torque value. Engine load was changed from 0 % to 100 %with an interval of % 10 engine loads by using electrical dynamometer. Before each test, the engine was warmed up with diesel fuel for about 15min until the engine temperature stabilized. An electrical dynamometer was used for the measurement of torque and power output.

Two different exhaust emission analyzers were used: CO and NO_x emissions were measured by using CAPELEC and total HC emissions were measured SUN MGA 1500 test devices, respectively.

Table.2 Specification of the test engine

Model of Engine	Lister Petter AA1
Number of cylinder	*1*
Cylinder Diameter (mm)	*69,85*
Stroke (mm)	*57,15*
Swept Volume (cm^3)	*219*
Compression Ratio	*17:1*
Recommended maximum speed (rpm)	*3000*
Power (EN DIN 70020) (kW)	*2,2*
Maximum torque (Nm)	*22*
Fuel consumption (lt/h)	*1,7*
Oil consumption (kg/h)	*0,003*
Hole weight (kg)	*57*

Mixtures of trout oil methyl ester and diesel fuel were evaluated as test fuels. These fuel blends were named B20 (%20 trout oil + %80 Diesel fuel), B40 and B50. For all fuel blend tests, the exhaust temperature distribution by engine load was measured using K-type thermocouple from exhaust line.

3. Results and discussion

At different load condition exhaust emissions were measured. Total hydrocarbon (ppm), carbon monoxide (%), Nitric oxide (NO_x ppm), exhaust gas temperature and oxygen consumption were plotted. HC ppm emissions are presented in Fig.2

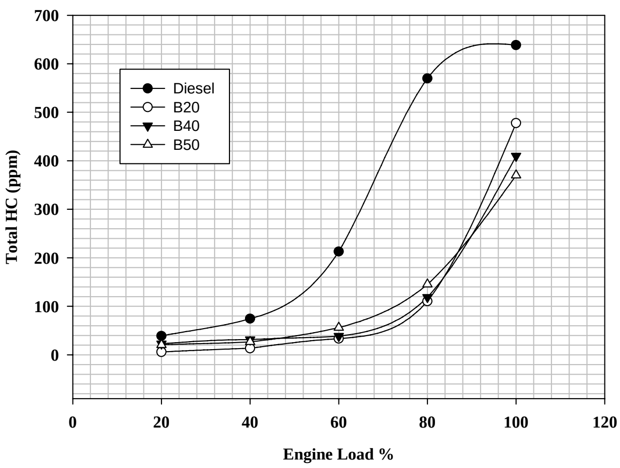


Figure.2 Effect of fuel blends on carbon monoxide emission

Biodiesel is oxygenated fuel (hence more complete combustion) and causes lesser particulate formation and emission. Experimental investigations are performed on single cylinder IDI diesel engines with trout oil methyl esters and found that hydrocarbon emissions are much lower in case of biodiesel-diesel blends compared to diesel.

This is also due to oxygenated nature of biodiesel where more oxygen is available for burning and reducing hydrocarbon emissions in the exhaust. The NO_x (ppm) and exhaust gas temperature are represented in Fig.4 and Fig.5 respectively.

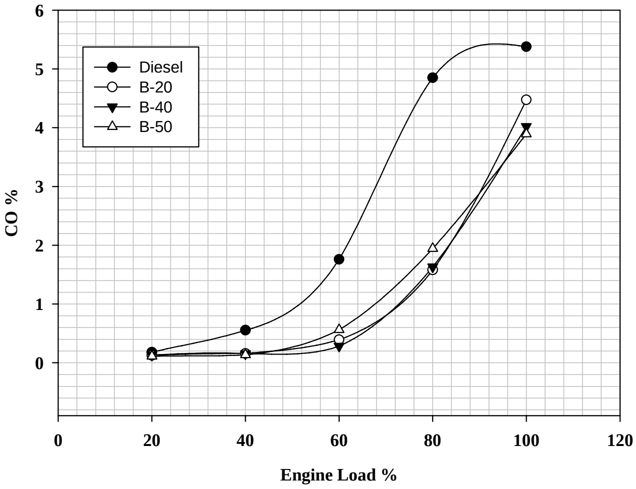


Figure.3 Effect of fuel blends on carbon monoxide emission.

CO is a toxic combustion product resulting from incomplete combustion of hydrocarbons. CO, formed by the incomplete combustion of fuels, is produced most readily from petroleum fuels, which contain no oxygen in their molecular structure. In presence of sufficient oxygen, CO is converted into CO_2. Biodiesel is an oxygenated fuel and leads to more complete combustion; hence CO emissions reduce in the exhaust. Since trout oil ester ''oxygenated'' compounds contain oxygen, the result is a substantial reduction in CO emissions.

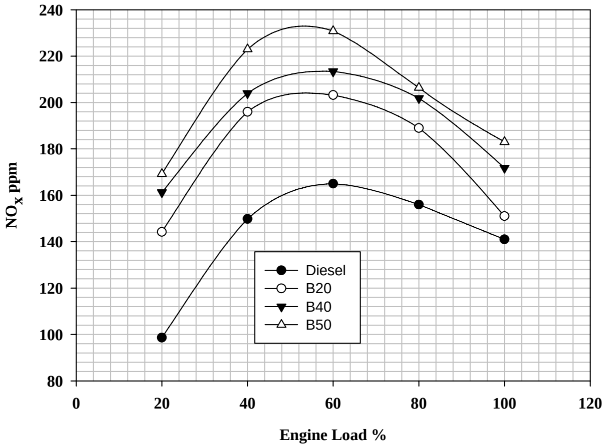


Figure.4 Effect of fuel blends on NO_x emission.

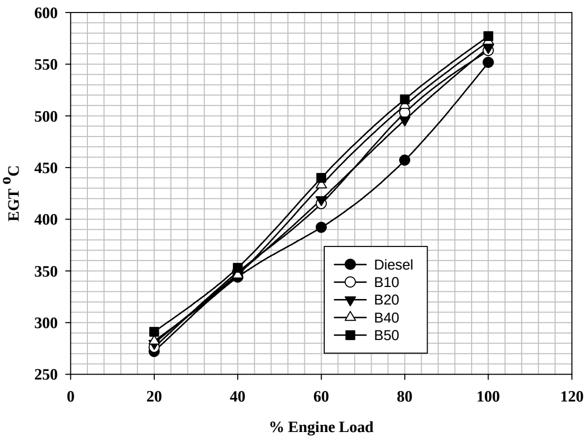


Figure.5 Effect of fuel blends on exhaust temperature.

The NO_x forms by oxidation of atmospheric nitrogen at sufficiently high temperatures. Kinetics of NO_x formation is governed by Zeldovich mechanism, and its formation is highly dependent on temperature and availability of oxygen. The experimental results showed that slight increase in NO_x emissions for biodiesel-diesel fuel blends. The oxygen consumptions of diesel-biodiesel fuel blends are presented in Fig.6.

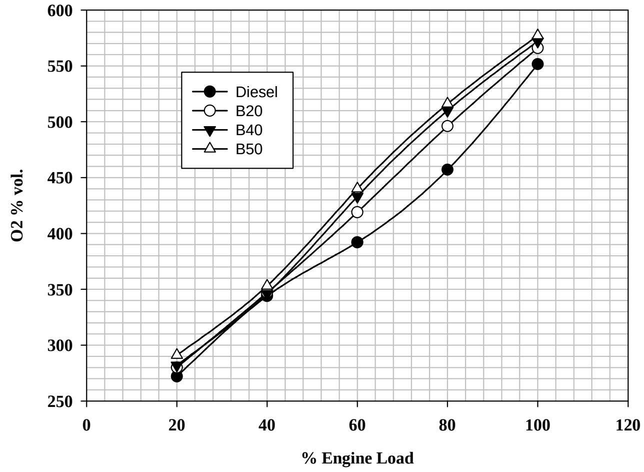


Figure.6 Effect of fuel blends on oxygen consumption.

It is quite obvious, that with biodiesel, due to improved combustion, the temperature in the combustion chamber can be expected to be higher and higher amount of oxygen is also present, leading to formation of higher quantity of NO_x in diesel-biodiesel blends.

4.Conclusion

Biodiesel has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. A continuous transesterification process is a method of choice to lower the production cost. Researchers in various countries carried out experimental research using vegetable and animal oils and biodiesel as petroleum fuel substitutes. Oil methyl esters gave performance and emission characteristics comparable to that of diesel.

Esterification is a process, which brings about a change in the molecular structure of the oil molecules, thus bringing down the levels of viscosity and unsaturation of vegetable and animal fat oils. The viscosity of vegetable and animal fat oils get drastically reduced after esterification. A 20% blend of biodiesel with mineral diesel improved the cetane number of diesel. The calorific value of biodiesel was found to be slightly lower than mineral diesel. All these tests for characterization of biodiesel demonstrated that almost all the important properties of biodiesel are in very close agreement with the mineral diesel making it a potential candidate for the application in CI engines. A diesel engine can perform satisfactorily on biodiesel blends without any engine hardware modifications.

The B20 biodiesel-diesel fuel blend was found to be the optimum concentration for biodiesel blend, which improved the peak thermal efficiency of the engine, reduced the exhaust emissions and the brake specific energy consumption substantially. However, biodiesel's lower sulfur content allows the use of NO_x control technologies that cannot be otherwise used with conventional diesel. Hence biodiesel's fuel NO_x emissions can be effectively managed and eliminated by engine optimization. Esterification has been found to be an effective technique to prevent some long-term problems associated with utilization of vegetable and animal fat oils such as fuel filter plugging, injector coking, formation of carbon deposits in combustion chamber, ring sticking, and contamination of lubricating oils. The carbon deposits on piston top and injector coking substantially reduced in biodiesel-fueled system. The wear of various vital parts reduced up to 30% because of additional lubricity properties of biodiesel. Hence, biodiesel-diesel fuel blends may be considered as diesel fuel substitutes. The use of biofuels as IC engine fuels can play a vital role in helping the developed and developing countries to reduce the environmental impact of fossil fuels.

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