Experimental Investigation of Performance and Emission Characteristics of a CRDI Engine Fueled with Fish Biodiesel

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Abstract -*With the increasing population there is an ever increasing demand for the fuel for various needs. The depletion of fossil fuels and the pollution caused by the use of fossil fuels has created a strong demand to find a more eco-friendly alternative for the present fossil fuels which are currently being used.Biodieselrefersto the product obtained after the process of Transesterification of animal fat or vegetable oil consisting of long chain alkyl esters. Biodiesel can either be used as an alternative for diesel directly or it can also be blended with diesel in any proportions. In this study, we use fish oil blended with diesel i.e. 20% of fish oil was blended with diesel which is represented as B20. This blend was tested on a single cylinder CRDI engine at varied pressures and the composition of exhaust was tabulated along with the Specific Fuel Consumption and Brake Thermal Efficiency and was compared with that of diesel. It was found that the NOx emissions increased while UBHC and CO emissions decreased when compared with diesel. The efficiency remained almost same as that of diesel with slight variations.)*

Key Words:Waste fish oil, Biodiesel, Transesterification, CRDI, Varied pressure.

1. INTRODUCTION

Fossil fuels have been the principal source of energy to power this planet since their advent in the 18th century; of which diesel is of utmost importance because of its superior qualities like higher thermal efficiency, durability and lower fuel consumption. However, the escalating rate of diesel fuel consumption, increased outflow of foreign exchange and its detrimental impact on the environment has induced researches to search for alternate fuels.Biodiesel as one of the form of important biofuel type is made from vegetable oils and animal fats. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide and hydrocarbons from diesel powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel.Currently there is increased interest in the use of post-production or post-processing waste products (second gen raw material) for biodiesel production. The use of feedstock of this type does not cause ethical objections related to the processing of food for fuel and provides reasonable opportunities for the disposal of products considered as waste in other sectors of economy. Economic considerations are strong as well. The high supply of materials considered to be waste and need to recycle them provides easy access to feedstock for below. The price of the competing 1st generation bio-materials.Note that bio-diesel obtained from waste can sometimes be characterized by worse physical and chemical properties compared to the product obtained from previously unprocessed feedstock. If means that obtaining a high quality biofuel requires additional work related to the preparation of the feedstock and use of more sophisticated production techniques.These steps are necessary when using biofuel in modern Common Rail Direct Injection systems, which require high quality fuels with properties that do not meet the quality requirements laid down by relevant standards. The below Table. 1 shows the abbreviations used and theFig. 1 shows the block diagram of the experimental setup.

Table -1: Abbreviations

BP	Brake power
BTE	Brake Thermal Efficiency
HRR	Heat release rate
B20	20% biodiesel+ 80% diesel
UBHC	Unburnt hydrocarbons
NOx	Nitrogen oxides

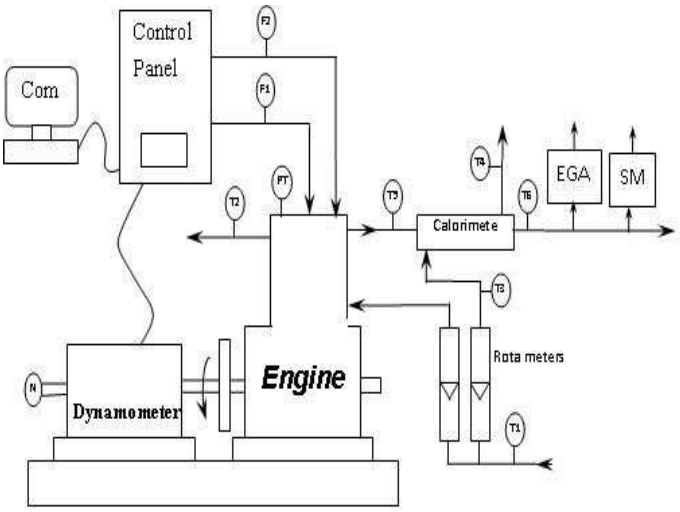

Fig -1: Block diagram of the experimental setup

2. EXPERIMENTAL DETAILS

2.1 Biodiesel extraction methods

The non-edible fish oil is used to produce the biodiesel fuel using a laboratory-scale setup.The setup consists of mechanical stirrer with controllable stirring speed and temperature, beakers, thermometer to observe the reaction temperature. The properties of both base diesel fuel and the received B20 are listed according to ASTM standard. Acid value determination:The acid value of fish oil has been determined by a standard titrimetric method as per European standardEN14104

2.2 Transesterification

Esterification setupA round bottom flask is used as laboratory scale reactor for these experimental purposes. A hot plate withmagnetic stirrer arrangement is used for heating the mixture in the flask. The mixture is stirred at the same speed for all test runs. The temperature range of 50-60oC is maintained during this experiment. Fig.1 shows the mechanism of transesterification process.

Acid transesterification:One litre of fish oil requires 600 ml of methanol for the acid esterification process. The poultrylitter oil is poured into the flask and heated to about 50°C. The methanol is added with the preheated fish oiland stirred for a few minutes. 0.5% of sulphuric acid is also added with the mixture. Heating and stirring is continued for 30–50 min at atmospheric pressure. On completion of this reaction, the product is poured into aseparating funnel for separating the excess alcohol. The excess alcohol, with sulphuric acid and impurities moves to the top surface and is removed. The lower layer is separated for further processing (base esterification).

Base transesterification:Alkaline catalysed esterification process uses the experimental setup of acid catalysed pre-treatmentprocess. The products of first step are preheated to the required reaction temperature of 55±5oC in the flask.Meanwhile, 30ml of oil is taken in a round bottom flask 0.24 g of KOH is dissolved in 15 ml methanol and is poured into the flask. The mixture is heated and stirred for 40-50 min. The reaction is stopped, and the products are allowed to separate into two layers. The lower layer, which contained impurities and glycerol, is drawn off. The ester remains in the upper layer. Methyl esters are washed to remove the entrained impurities and glycerol. Hot distilled water (10% by volume) is sprayed over the surface of the ester and stirred gently. Lower layer is discarded and yellow colour layer (known as biodiesel) is separated.

2.3Preparation of blend

B20 is prepared by mixing 20% by volume of biodiesel with 80% of diesel in a beaker andconstantly stirred for 15 minutes on a magnetic stirrer.

2.4Experimental Details

Here, the engine is made to run under varied pressures [200 and 250bar] at constant speed. Load is varied as follows: 0kg, 2kg, 4kg, 6kg,8kg,9kg [since max. load of 10kg cannot be applied for varied pressure, 9kg is taken as max. load. Engine was initially operated with diesel and later it was operated by Bio-diesel [fish oil] blend[B20].

Table -2: Fuel properties

PROPERTIES	DIESEL	FISH OIL
Kinematic viscosity at 40°C, mm^3/s	3.05	24.31
Heat value kJ/kg	42.6	36.8
Density at 15°C, kg/m^3	828	895
Flash point °C	60	194
Cetane number	40	48

Performance properties like BTE calculated for diesel and B20 and also emission properties like amount of UBHC, CO, NOx and opacity are calculated. These above characteristics of Diesel and Bio-diesel are compared with each other.The table. 2 gives the characteristic properties of Biodiesel.

3. RESULT AND DISCUSSION

3.1 Performance parameters

3.1.1 Brake thermal efficiency

It is observed that BTE increases with load. The increase in BTE is due to the biodiesel which is rich in oxygen which helps in better combustion than the diesel. And the Biodiesel results in finer atomization than diesel which helps in rapid vaporization of the fuel reduce in incomplete combustion when compared to diesel. It is been known that the Brake Thermal efficiency increases with the increase in the load. The below graphs Fig.2andFig. 3 shows that the efficiency of B20 is higher compared to that of dieselat varied pressures.

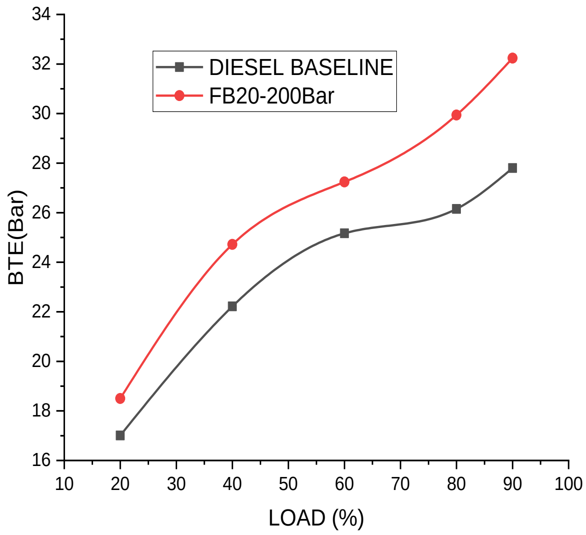

Fig -2: BTE versus LOAD at 200Bar

3.2 Emission parameters

3.2.1 Nitrogen oxides

It is observed that there is an increase of NOx emissions during Biodiesel operations compared to that of Diesel operations. As we know NOx emissions are highly temperature dependent, it increases with load due to increase in temperature. NOx emissions increases for Biodiesel due to the availability of more oxygen atoms compared to that of diesel which increases the combustion temperature as a result NOx increases. This reduced ignition delay and combustion timing are obtained when using the biodiesel blend. It is known that the shorter ignition delay may contribute to slightly increased NOx emissions with biodiesel blend. The graphs shown below Fig. 4 andFig. 5shows the increase in NOx emissions with respect to the load at varied pressures.

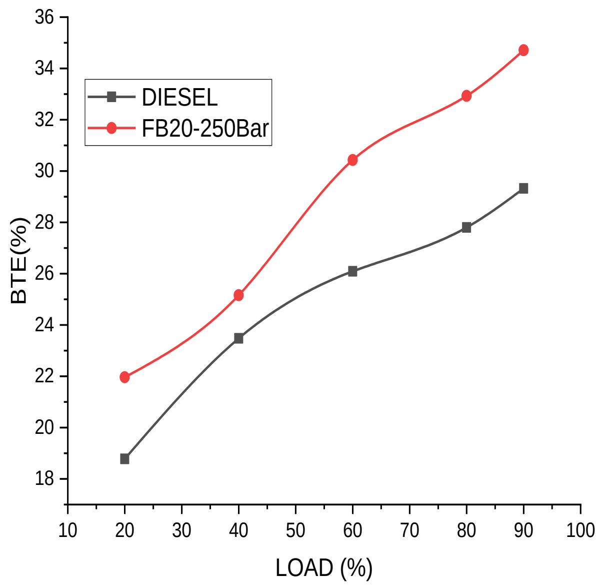

Fig -3: : BTE versus LOAD at 250Bar

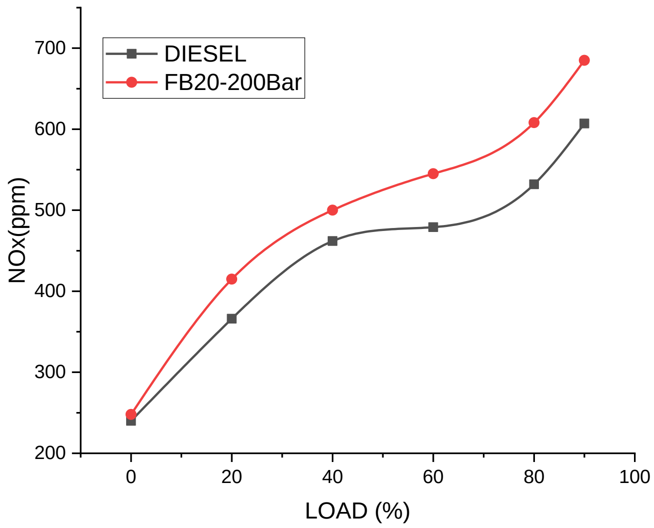

Fig -4:NOx versus LOAD at 200Bar

3.2.2 Carbon monoxide

It is observed that CO emissions of Biodiesel is lesser than compared to diesel fuel. The CO emissions and the o emissions are related in a way because these are the products of incomplete combustion. As the availability of oxygen is more in Biodiesel compared to that of diesel, the CO emissions reduces on the other hand the CO emissions increases with respect to load, this is due to the high viscosity of the Biodiesel,which affects the range and quality of the fuel spray.

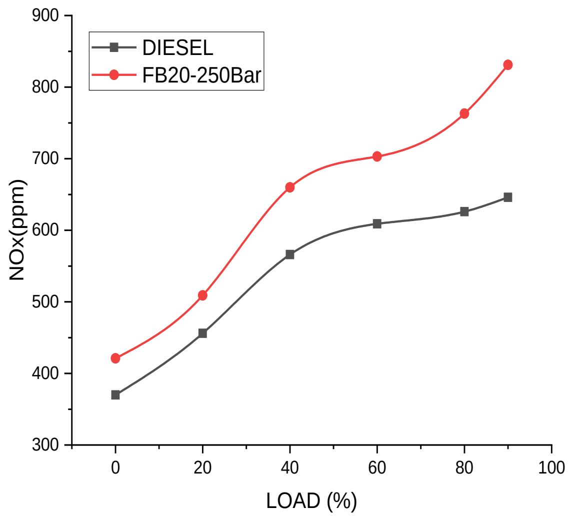

Fig -5:NOx versus LOAD at 250Bar

CO emissions is mainly due to the unavailability of oxygen atoms for complete combustion and the poor air treatment. Also higher cetane number, favorable fatty acid composition has a positive effect on the emission. It is also observed that for higher pressures the CO emissions has reduced slightly compared to that of lower pressure.The graphs shown below Fig. 6andFig. 7shows the relation with which CO increases with load at varied pressures.

3.2.3Unburnthydrocarbons

The cause of unburnt hydrocarbons is that no engine is 100% efficient, it is seen that in any engine all the fuel supplied is never completely burnt because of various factors as a result of this incomplete combustion there are particulate matter in the exhaust which are called as unburnt hydrocarbons. From the experimentation it is seen that the amount of UBHC increases with the increase in the load. But as the pressure increases the UBHC content in the exhaust of diesel is observed to decrease. So with increased pressure the amount of UBHC obtained in the exhaust of Biodiesel can be optimized. The graphs below Fig. 8 and Fig. 9shows the relation with which UBHC increases with load at varied pressures.

3.2.4Smoke opacity

Smoke opacity is the exhaust gases is the measure of particulate matter in the exhaust. This is due to the presence of oxygen and lower carbon content in biodiesel compared to that of Diesel. It is observed that the smoke opacity increases with the increase in load and reduces very slightly with the increase in pressure.The graphs below Fig-10 andFig-11shows how the smoke opacity increases with load at varied pressures.

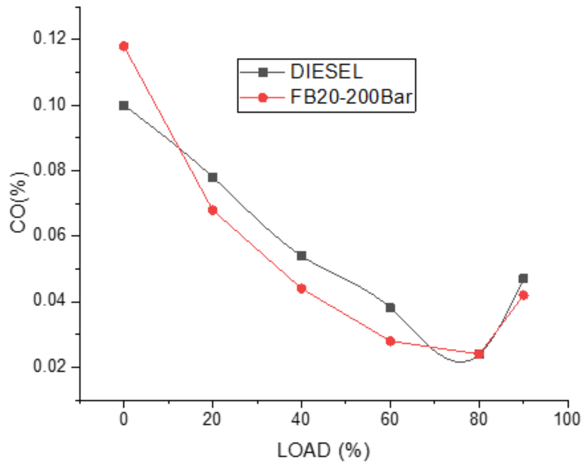

Fig -6:CO versus LOAD at 200Bar

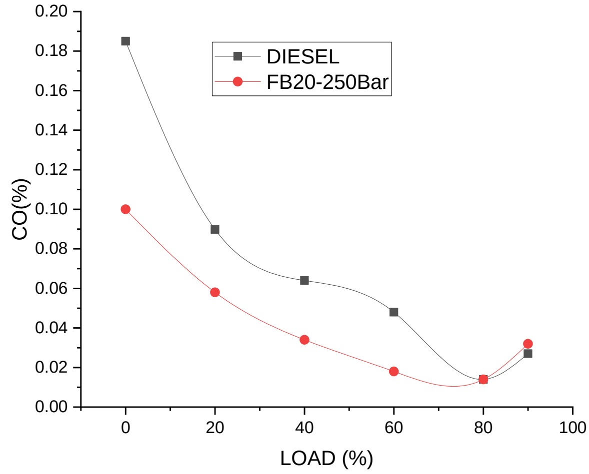

Fig -7: CO versus LOAD at 250Bar

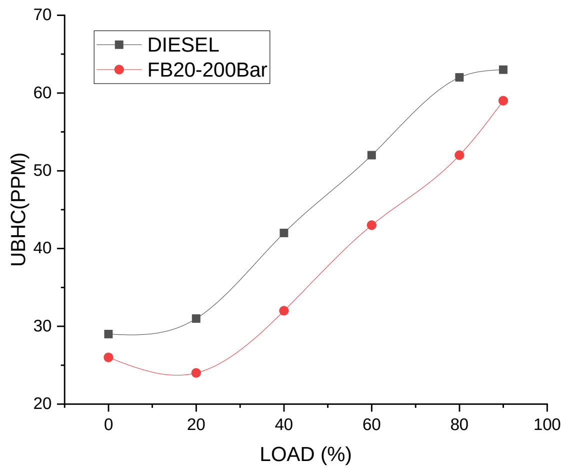

Fig -8: UBHC versus LOAD at 200Bar

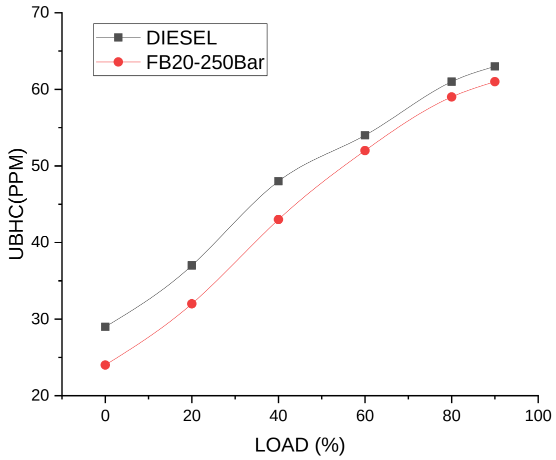

Fig -9: UBHC versus LOAD at 250Bar

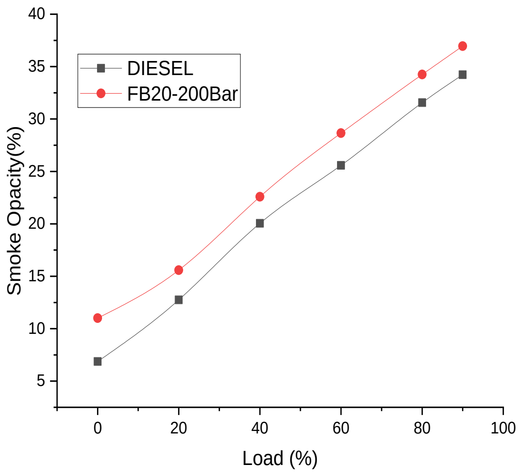

Fig -10: Smoke opacity versus LOAD at 200Bar

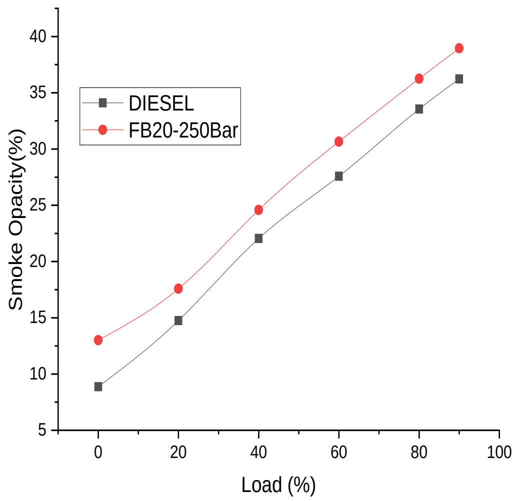

Fig -11: Smoke opacity versus LOAD at 250Bar

4. CONCLUSION

From the results obtained from the above data obtained from the experiment conducted in the single cylinder CRDI engine using the waste fish oil biodiesel with a blend of B20, we can come to a conclusion that the Brake thermal efficiency is higher for Biodiesel when compared to that of diesel along with the decrease in CO and UBHC which gives an added advantage to the Biodiesel blend. While there is an increase in NOx and smoke opacity which requires further study of the behavior of fuel.

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