Investigation on Performance and Emission Characteristics of Biodiesel Blends Extracted from Trash Fish Oil

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Abstract: **The present scenario is evidensing a large population density and increased pollution in the world. Many researchers have undergone to use biodiesel from waste resources like vegetable oils, animal fats, trash fish oil etc. The first step involves the production of biodiesel from trash fish oil. In this paper the performance and emission characteristics of single cylinder diesel engine fuelled with different blends of trash fish oil derived biodiesel and diesel are evaluated. Experiments were conducted with different blends of biodiesel and diesel at various conditions. The performance and emission characteristics are predicted and compared with plain diesel characteristics. Biodiesel provided significant reduction in HC and smoke at full engine load. The brake specific fuel consumption is higher for biodiesel due to its lower heating value. However it was observed that the emission characteristics of CO and CO_2 of the blends of trash fish oil with diesel followed closely with that of the base line diesel. It is found that using of biodiesel blends has improved performance rather than using biodiesel alone as fuel. Biodiesel blends are cost effective than separate biodiesel.**

Keywords: **Biodiesel, Trash fish oil, Combustion, Emission, Performance.**

I. INTRODUCTION

With a growing demand for transportation, Internal Combustion (IC) engines have gained lot of importance in automobile industry. It is therefore necessary to produce efficient and economical engines. While developing a Compression Ignition (CI) engine, it is required consider all the parameters affecting the engines design and performance. There are certain parameters which are difficult to account while designing an engine. So it becomes necessary to conduct tests on the engine and determine the measures to be taken to improve the engine performance. Brake power, Total fuel consumption, Specific fuel consumption, Torque, Brake Mean Effective pressure are the performance parameters discussed in this paper. The exhaust emissions are hydrocarbons, oxides of carbon, oxides of nitrogen, oxides of sulpher, particulate matter and smoke. Though several emission components are studied with respect to Biodiesel operated CI Engine. It is observed that NOx is a major component to be analysed deeply. There are many methods by which NOx is reduced. One of them is reducing the peak combustion temperature. The other simple way is by early injection of fuel into the combustion chamber which in turn increases fuel consumption. Another method is using techniques like Exhaust Gas Recirculation (EGR), helps in reducing NOx. But slight increase in particulate emission is observed.

Biodiesel has been identified as a versatile fuel and promising potential diesel alternative for diesel engine applications because of its characteristics such as renewable, biodegradable, comparable energy density, easily producible, domestically available, non toxic, low emissions, energy independent and self reliant. Hence it has been in use for the past more than a decade, although vegetable oil was employed by Rudolf Diesel in 1900 for his first ever diesel engine fuel. The lower cost of the petroleum diesel has so far attracted the world to use it as fuel in diesel engines until now. But nowadays due to global political turmoil and other reasons the cost of petroleum diesel has been increasing and crossing over the cost of some varieties of vegetable oil.

The developing countries are not able to afford edible oil feed stocks for biodiesel production as they are not self-sufficient for their culinary needs. Therefore these countries make their biodiesel from waste resources. Biodiesel extracted from trash fish oil is one of the most promising options among these.

II. LITERATURE REVIEW

Ganapathy T et al. (2009) [4] had done an Analytical and Experimental Study on Performance of Jatropha Derived Biodiesel Fuelled Engine. . There were many experimental studies of jatropha biodiesel fueled diesel engine reported in many literatures, yet theoretical study of this biodiesel run diesel engine is done only in few literatures. This work presents a theoretical thermodynamic study of single cylinder four stroke direct injection diesel engine fueled with biodiesel derived from jatropha oil. The results of the model are compared with experimental results. The variation of cylinder pressure with crank angle for various models are also compared and presented. The effects of injection timing, relative air fuel ratio and compression ratio on the engine performance characteristics for diesel and jatropha based biodiesel fuels are then investigated and presented in this paper.

Sharanappa Godiganur, et al. (2009) [6] had done Performance and emission characteristics of a Kirloskar HA394 diesel engine operated on fish oil methyl esters. The best way to use fish oil in compression ignition (CI) engines is to convert it into biodiesel so that it can be used in CI engines with very little or no engine modifications. This is because the properties of fish oil methyl esters are similar to mineral diesel. The tests showed no major deviations in diesel engine's combustion as well as no significant changes in the engine performance and reduction of main noxious emissions with the exception on NOx. Overall fish biodiesel showed good performance and combustion charecteristics.

Hari Prasad T et al. (2011) [3] had done Combustion, Performance and Emission Analysis of Diesel Engine fuelled with Methyl Esters of Fish oil. A Computer assisted Single cylinder constant speed water cooled four stroke direct diesel engine (5 H.P) which is commonly used in the agricultural sector for driving the pumps and small electrical generators is selected for the experimental investigation. The performance, emissions and combustion characteristics are analyzed. The combustion parameters considered for this analysis are cylinder pressure and heat release rate. The brake thermal efficiency is slightly reduced and hydrocarbon, carbon monoxide and smoke emissions in the exhaust are reduced when fueled with methyl esters compared to diesel. But the NOx emissions are high when compared with diesel.

Sivakumar V.R et al. (2010) [7] had done work on Statistical Analysis on the Performance of Engine with Jatropha Oil as an Alternate Fuel. Vegetable oils - due to their properties being close to diesel fuel can be used as promising alternative in diesel engine. But, their high viscosity prevents them from using it directly in an engine. Present investigation focuses on the use of Jatropha curcas seed based oil as fuel in diesel engine by blending it with diesel for dilution of viscosity and preheating it for reduction of viscosity.

Arun Balasubramanian K et al. (2010) [2] had done work on performance and emission characteristics of two biodiesel blends with diesel. Recent research on biodiesel focused on performance of single biodiesel and its blends with diesel. The combinations of Pongamia pinnata biodiesel, Mustard oil biodiesel along with diesel (PMD) and combinations of Cotton seed biodiesel, Pongamia pinnata biodiesel along with diesel (CPD) are taken for the experimental analysis. Experiments are conducted using a single cylinder direct-injection diesel engine with different loads at rated speed 3000 rpm. The engine characteristics of the two sets of two biodiesel blends are compared. For the maximum load, the value of Specific Fuel consumption and thermal efficiency of CPD-1 blend (10:10:80) is close to the Specific Fuel consumption of diesel. CPD blends give better engine characteristics than PMD blends.

Aransiola .E.F, et al. (2012) [1] had done work on Production of biodiesel from crude neem oil feedstock and its emissions from internal combustion engines. This study investigates biodiesel production using crude neem oil having high acid value, as a feedstock. The effects of some operating variables were ascertained and its combustion performance was assessed in an internal combustion engine. Due to its high acid value, the neem oil was processed via two step acid – base transesterification process. The emissions of different blends showed that neem biodiesel has lower emissions of CO and NO than petrol diesel but higher NOx. Thus, neem oil as non-edible oil can be a good renewable raw material for biodiesel production.

Jon Van Gerpen (1996) conducted Comparison of the Engine Performance and Emissions Characteristics of Vegetable Oil-Based and Animal Fat-Based Biodiesel. Biodiesel fuels produced from vegetable oils and animal fats are very similar. They contain the same chemical compounds but in different amounts. The fuels respond in a similar manner when burned in a diesel engine. Both fuels reduce unburned hydrocarbons, carbon monoxide, and particulates and both cause slight increase in the oxides of nitrogen. The differences in the measured values of the pollutants from the two fuels are within the range experienced with conventional diesel fuels from different refineries. There does not appear to be any basis for making a distinction between the two fuels in terms of their impact on engine performance and emissions.

III. METHODOLOGY

A .Production of biodiesel

Trash fish oil may be produced by crushing the fish of low cost value. Sardine fish is a low cost value fish. Hence it may be transformed into fish oil. This fish oil is purchased from ARBEE Fish Oil Company, Kotayam, Kerela. The biodiesel is extracted from trash fish oil by transesterification process. Then the biodiesel is purified and tested for the required properties like density, viscosity and calorific value.

B .Engine Testing

Experiments were conducted in a single cylinder 4 stroke DI diesel engine coupled with an Eddy current dynamometer.Thermocouples were installed in several locations to measure the exhaust gas temperature, EGR temperature and cooling water temperature. Fuel consumption was measured using gravimetric fuel consumption meter. Exhaust gas emissions were measured using AVL DIGAS 4000 LIGHT gas analyser and the smoke opacity was measured using smoke opacity meter (Make: AVL, Model: 407). The specification of the test engine is shown in table 1.

Table 1. Specifications of test engine

Make and model	Kirloskar SV1
General details	Four stroke, water cooled, direct injection
Rated power	5.9 Kw
Rated speed	1800 rpm
Loading type	Eddy current loading
Bore	87.5 mm
Stroke	110 mm
Compression ratio	17.5 : 1

IV RESULTS AND DISCUSSION

To achieve the objective of the study, the engine was run at different loads at 1800 rpm with pure diesel and diesel blends like B20, B40, B60 and B80. The engine performance, emission characteristics are predicted and plotted. The data for fuel consumption, exhaust gas temperature, HC, NO_x, CO, smoke opacity, pressure versus crank angle diagram and heat release diagram were recorded. Then, engine performance and emission patterns were analysed and presented graphically.

A Engine Performance Analysis

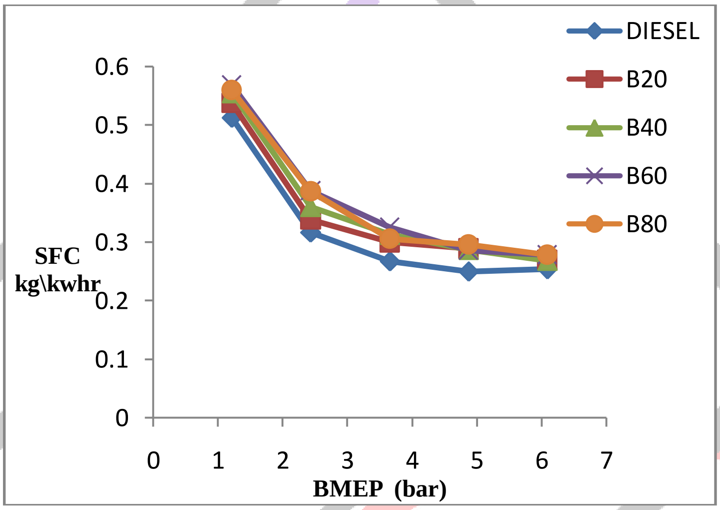

Fig 1: Variation of Specific Fuel Consumption (SFC) with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends.

Figure 1 represents the variation of Specific Fuel Consumption (SFC) with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends. The specific fuel consumption is higher for biodiesel blends at all loading conditions compared to diesel. This is due to lower calorific value of biodiesel blend therefore more amount of fuel is required to produce the same brake mean effective pressure.

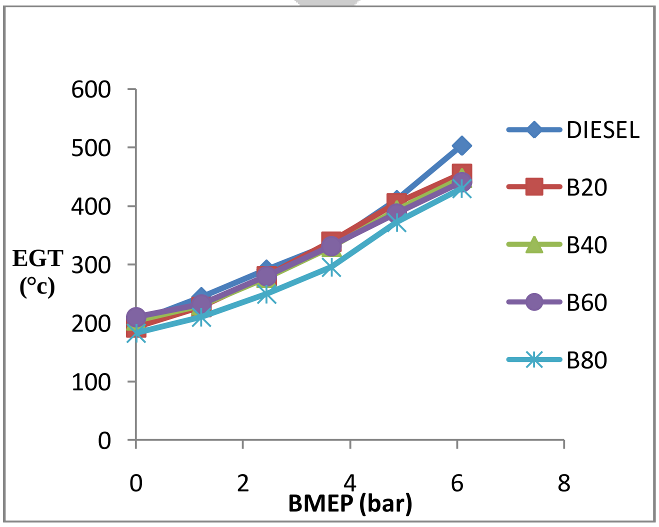

Fig 2: Variation of Exhaust gas Temperature (EGT) with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends.

Figure 2 shows the variation of exhaust gas temperature (EGT) with brake mean effective pressure (BMEP) for diesel and different biodiesel-diesel blends. It has been observed that with increase in load, exhaust gas temperature decreases and at full load conditions the exhaust gas temperature is lower than diesel. The reasons for temperature reduction are relatively lower availability of oxygen for combustion and higher specific heat of intake air mixture.

B Engine Emission Analysis

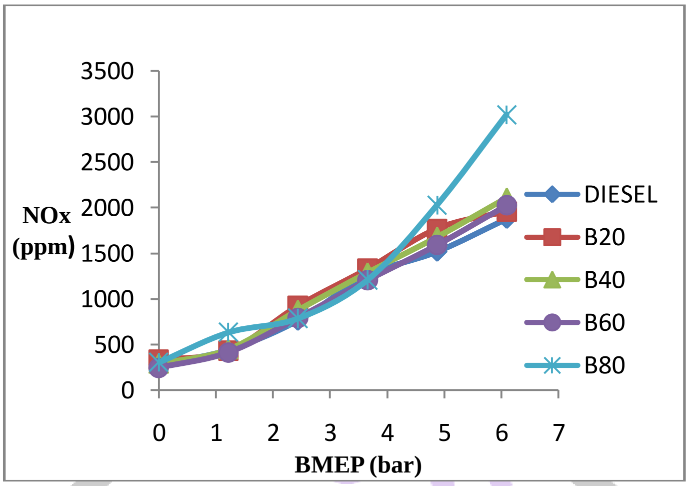

Fig 3: Variation of oxides of nitrogen with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends.

The variation of NO_X with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends is shown in figure 3. As load increases, the NO_X emission also increases. NO_X emission of B80 is higher than diesel because of its higher combustion temperature. This proves that the most important factor for the emissions of NO_X is the combustion temperature in the engine cylinder and the local stoichiometry of the mixture.

Figure 4 shows the variation of HC emissions with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends. It is observed that HC emission decreases at higher loads. This is because of better combustion of biodiesel inside the combustion chamber due to the availability of oxygen atom in biodiesel.

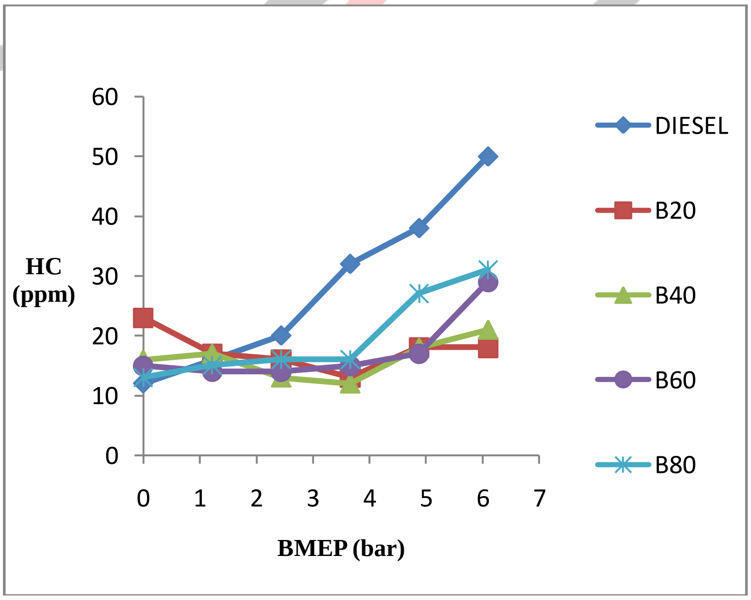

Fig 4: Variation of Hydrocarbon Emission with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends.

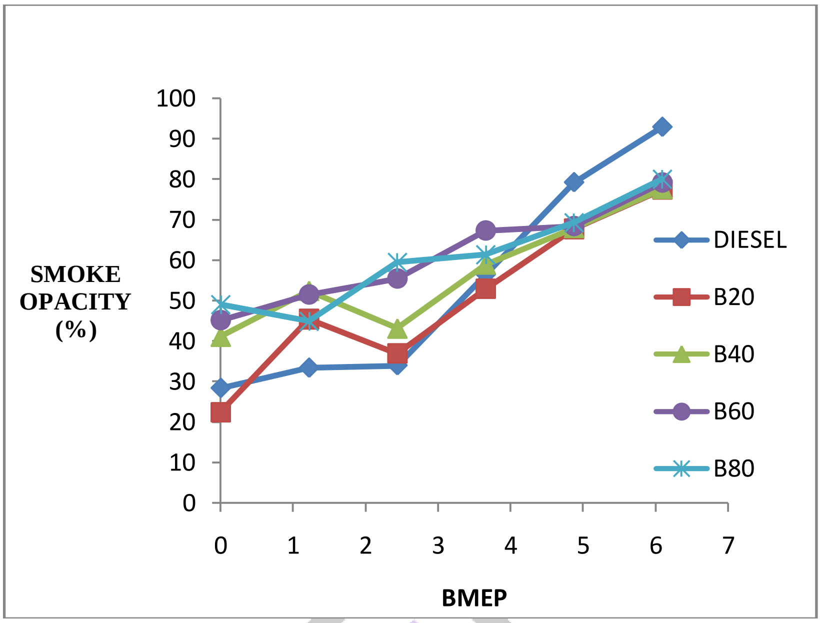

Fig 5: Variation of Smoke Opacity with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends.

The smoke opacity of the exhaust gas is measured to quantify the particulate matter present in the exhaust gas. The variation smoke opacity with Brake Mean Effective Pressure (BMEP) for diesel and different biodiesel-diesel blends is shown in figure 5. The smoke opacity of biodiesel blends are low at higher loads due to high fuel consumption at full loads. On other loads it is high. The oxides of carbon like CO and CO_2 of biodiesel blends slightly varies with diesel. This is because the properties of fish oil biodiesel are almost equal to that of diesel.

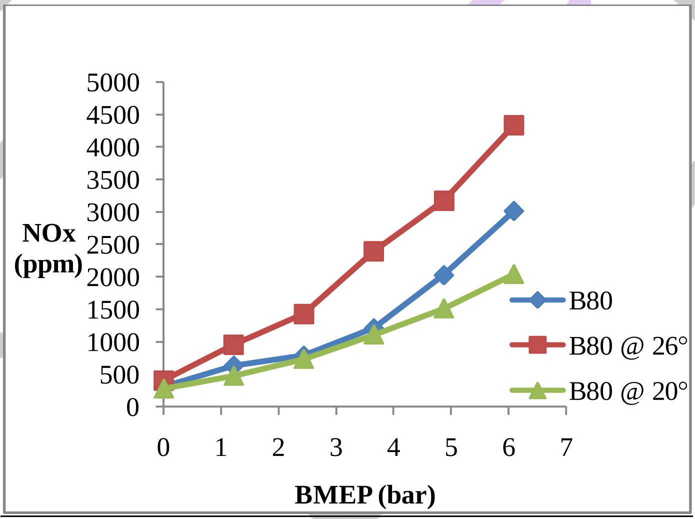

Fig 6: Variation of NOx with Brake Mean Effective Pressure (BMEP) with variation of injection timing for diesel and different biodiesel-diesel blends

As discussed earlier B80 has higher NOx emission when compared to other blends. In order to reduce the NOx emission, the injection timing is varied. The fuel is injected at both 26° and 20° of the crank angle and the NOx emission is compared graphically in figure 6. It shows that injecting the fuel at 20° crank angle has reduced NOx emission.

V CONCLUSION

The single cylinder diesel engine was operated successfully with diesel and biodiesel blends like B20, B40, B60 and B80. The following conclusions are drawn based on the investigation.

- The specific fuel consumption for biodiesel blends are 14% higher than diesel.
- There is an increase in NO_X for B80 and it decreases by 32 % when the fuel is injected at 20° crank angle.
- At full load, exhaust gas temperature decreases marginally for all biodiesel blends.
- HC emission decreases heavily at full load conditions for all biodiesel blends.

- Smoke opacity high at low loads and low at high loads.
- NOx emission can be reduced for biodiesel blends by injecting the fuel at the crank angle 20°.

It is concluded that biodiesel blends can be used in CI Engine by pre-injection of fuel in the combustion chamber.

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