EMISSION CHARACTERISTICS OF DIESEL ENGINE FUELED WITH ALGAE BIODIESEL-DIESEL BLENDS

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Abstract- *Increasing consumption of petroleum fuels all over the world and limitations to the extraction of it has led to measurable increase in its prices per liter. Also, a concern towards its environmental effects is limiting its use. This is asking for an alternate fuel source which will provide a comprehensive solution. Biodiesel is one of the alternatives which are being widely studied. Production of biodiesel from oil seeds is limited by crop land displacement. Production of biodiesel from algae is a promising option. As it is cultivated in ponds, there will be no crop land displacement and its yield is more than that of oil seeds. The present work aims to focus on the performance of a diesel engine with algae oil as fuel. In order to use the oil in engine, its blends with the petroleum diesel were prepared. The properties of algae oil and its blends were tested and the results were compared with properties of neat diesel. It is found that, the properties of neat algae oil and its blends are very close to the properties of neat diesel. Also the calorific value of the blends of algae oil is very close to neat diesel. The results of the tests are inspiring for the aim of this project. The prepared blends were used to run a variable compression ratio engine and its performance is studied. The result shows small reduction in torque, brake power and brake thermal efficiency. Also the specific fuel consumption increases with increase in blending ratio. The emissions of CO, CO2 and HC decreased with slight increase in emission of NOx. B10 blend shows good overall result. However it can be concluded that, algae biodiesel can be blended with straight diesel up to 20% to use in a diesel engine without any modification.*

Key Words:Algae, Biodiesel, Emissions

1. INTRODUCTION

India is one of the fastest growing markets in the world. The economic growth of country is driving energy consumption across all major sectors. It's making India fourth largest primary energy and petroleum consumer [7]. As the country has limited resources, it makes us think of an indigenous source. Biodiesel, from long is being studied as a promising alternative.

India being an agricultural country, assures enough raw material to produce biodiesel from edible and non-edible oil seeds. However, food security may restrict us to use only nonedible sources for production of biodiesel. Jatropha, rapeseed, soybean, palm, sunflower oils are mostly used for production of biodiesel. Apart from oil seeds, animal fats can also be used for production of biodiesel.

Though the oil seeds are very regular source for production of biodiesel, it's associated with the problem of crop land displacement. The land which will be used for production of these oil seeds is the same which was producing edible sources. Hence the total land availability for production of edible sources might decrease. This, in turn, will reduce the production of edible oil, increasing their prices. Production of biodiesel from microalgae could be a comprehensive solution to this problem. As these could be grown in ponds or bioreactors, crop land displacement can be avoided. Hence it proves to be a very good alternative along with their better yield than oil seeds.

2. OVERVIEW OF ALGAE BIODIESEL

Algae are unicellular or multi cellular organisms that photosynthesize, but lack the features such as leaves, roots, seeds and flowers. They can commonly be found in aquatic—both freshwater and marine—environments. The microalgae can be grown in both open-culture systems such as ponds, lakes and raceways, or in highly controlled closed-culture systems like photo bioreactors, similar to those used in commercial fermentation processes. The photosynthetic growth of micro algal biomass require light, carbon dioxide, water, organic salts and temperature of 20- 30°C. Cultivating algae in open system is most economical, as it requires least expenses. But the biomass produced in such open system is limited and to increase the yield, closed culture system can be used.

The algal oil is found inside plant cells, linked with proteins and a wide range of carbohydrates like starch, cellulose, hemi-cellulose and pectin. The cell content is surrounded by rather thick wall which has to be opened so the protein and oil can be released. Various methods are available for the extraction of algal oil, such as mechanical extraction with hydraulic or screw, enzymatic extraction, chemical extraction through different organic solvents,

Ultrasonic extraction and supercritical extraction using carbon dioxide.
Biodiesel can be produced by transesterificaton of algal oil. The transesterification is the reversible reaction of fat or oil (which is composed of triglyceride) with an alcohol to form fatty acid alkyl ester and glycerol. The reaction occurs stepwise: triglycerides are first converted to diglycerides, then to monoglycerides and finally to glycerol [18].
Microalgae are capable of synthesizing more oil per acre than the terrestrial plants as they can double their biomass within 24 hrs [19]. Hence using microalgae to produce biodiesel will not compromise production of food, fodder and other products derived from crops.

3. EXPERIMENTAL SETUP

In the present work, the performance of different blends of diesel-biodiesel is studied in diesel engine. For this purpose, different blends of petroleum diesel and biodiesel were prepared and named B00, B10, B20 and B30. Here, B00 is neat diesel and is used to compare the performance of biodiesel. B10, B20 and B30 are the blends of diesel and algae biodiesel where algae biodiesel is mixed with diesel in proportion of 10%, 20% and 30% respectively by volume.
The engine used for the experimentation is Kirloskar single cylinder diesel engine. Being a VCR engine, the compression ratio can be varied between 12 and 18. The hydraulic dynamometer is used to apply the load on engine output shaft. Data acquisition system is used to collect various parameters of engine. A software "Engine soft" is used to analyze the data. "AVL Digas 444" is a five gas analyzer used for analyzing the emissions of engine.

Table 1:Engine Specifications

Engine Make	Kirloskar TV1 VCR Engine
Number of Cylinders	1
Cycle	4 Stroke
Rated Power	3.5 KW @ 1500 rpm
Cylinder Diameter	87.5 mm
Stroke Length	110 mm
Connecting Rod Length	234 mm
Compression Ratio	12 to 18
Cooling Medium	Water Cooling

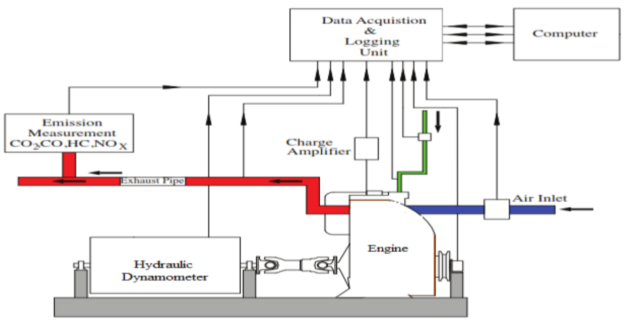

Fig1: Experimental Setup

4. RESUTS AND DISCUSSION

4.1 Effect of Biodiesel Properties

In order to characterize, the properties of bends were studied and compared with diesel. It is found that, the properties of algae biodiesel-diesel blend are very close to the properties of petroleum diesel.

a. Density

Density is measure of mass per unit volume of a material. Biodiesels, in general, are characterized by higher densities than conventional petroleum diesel. This means, volumetrically operating fuel pumps will inject greater mass of fuel. This will affect the air fuel ratio of the engine [14].In present study, density of biodiesel blends is found to be increasing with the increase in blend ratio.

b. Viscosity

It is measure of internal resistance to flow of a fluid. Higher viscosity of fuel enhances fuel spray penetration and thus improves air fuel mixing [38]. However fuel with higher viscosities cannot be used safely in compression ignition engines [14]. It is seen that the viscosity of blend increases with increase in blending ratio. This limits the blending ratio of diesel and biodiesel.

c. Calorific Value

Calorific value is the measure of heat content of fluid or fuel. It is very well established that, calorific value of biodiesel is lower than petroleum diesel. The same is observed in the study. This also reduces the calorific value of biodiesel blends. This, in turn, means that more fuel will have to be consumed for getting same work output from an engine which is using petroleum diesel. This will increase the specific heat consumption and may lower the torque and power output of the engine.

d. Cetane Number

Cetane number is one of the most important characteristic of fuel. It is a dimensionless number and indicates the ignitability of the fuel [14]. Higher cetane number of fuel promotes faster auto ignition of fuel and reduces the emissions of nitrogen oxides [14]. Cetane number of biodiesel blends in present study is found to be higher than diesel, which creates a possibility of better combustion and knock free working of engine.

4.2 Exhaust Emissions

Engine trails were conducted at different loads and different compression ratio. At these conditions the exhaust emissions were measured. The result is as tabulated below. In the present work, four major emissions are considered viz. CO, CO2, HC and NO. Study shows a minor decrement in emissions of CO and HC for lower loads. At higher loads emissions of HC are almost similar to that of diesel. B20 blend shows better results for emissions of CO and HC. Emissions of nitrogen oxides are increases with increase in blend ratio. This may be due to improved automation of biodiesel blends and higher temperatures.

a. Carbon Monoxide and Carbon Dioxide

Carbon monoxide is colorless, odorless poisonous gas. It is generated when engine is operated with fuel rich mixture. It is indicative of incomplete combustion. The study shows a decrement in emissions of carbon monoxide and carbon dioxide for all blends and all loading conditions. The emissions are slightly more for all the blends at lower compression ratio and lower load. Graph below shows the carbon monoxide and dioxides at 100% load and compression ratio of 17.5

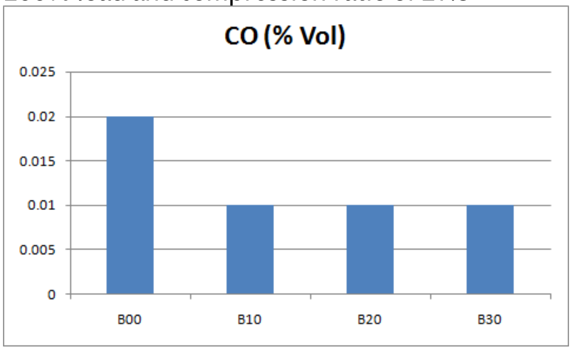

Chart -1: Comparison of CO Emissions
(100% Load, C.R. 17)

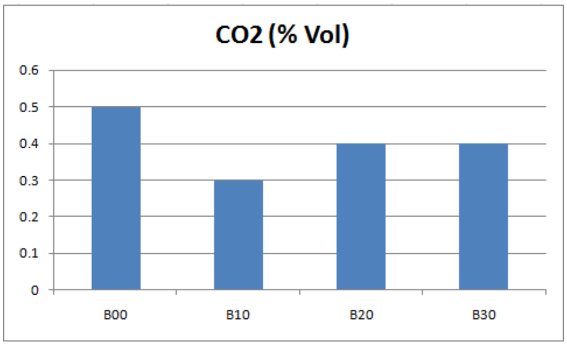

Chart -2: Comparison of CO_2 Emissions
(100% Load, C.R. 17)

b. Hydrocarbon (HC)

Hydrocarbon emissions depend on combustion efficiency of the engine. Some fuel particles may condense on the surface of soot. Diesel engines have higher HC emissions. However, it can be observed that, hydrocarbon emissions reduce with increasing load. The study shows minimum hydrocarbon emissions at 100% load and compression ratio of 17.5. Also for all other loading conditions, biodiesel blend show decrement in HC emissions. Graph below shows HC emissions at 100% load and compression ratio of 17.5.

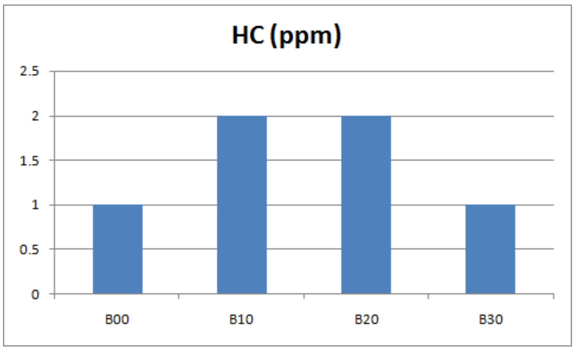

Chart -3: Comparison of HC Emissions
(100% Load, C.R. 17)

c. Nitrogen Oxides (NOx)

It is created mostly from nitrogen in the air. The reaction takes place at higher temperatures. In addition to this, formation of NOx also depends on availability of excess oxygen. Because of this emission of NOx increase in biodiesel blends as compared to straight diesel. It is observed that, emissions of NOx increased for all blends and all loading conditions. Also, it can be observed that, emissions of NOx increase with increase in blending ratio. Graph below shows the comparison of NOx emissions at 100% load and compression ratio of 17.

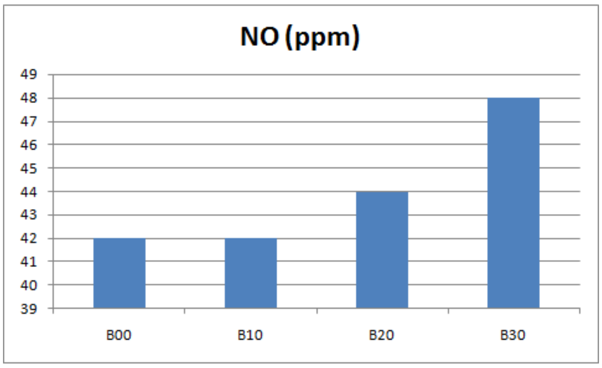

Chart -4: Comparison of NOx Emissions
(100% Load, C.R. 17)

	CO (% Vol.)	CO2 (% Vol.)	HC (ppm Vol)	NO (ppm Vol)
B10, C.R. – 15, 60% Load	0.03	0.60	7	7
B20, C.R. – 15, 60% Load	0.02	0.60	5	21
B30, C.R. – 15, 60% Load	0.02	0.60	7	14
B10, C.R. – 15, 100% Load	00	0.30	5	23
B20, C.R. – 15, 100% Load	00	0.40	1	31
B30, C.R. – 15, 100% Load	0.01	0.40	9	27
B10, C.R. – 17, 60% Load	0.01	0.80	4	41
B20, C.R. – 17, 60% Load	0.02	0.80	2	31
B30, C.R. – 17, 60% Load	0.01	0.40	5	48
B10, C.R. – 17, 100% Load	0.01	0.30	2	18
B20, C.R. – 17, 100% Load	0.01	0.40	2	44
B30, C.R. – 17, 100% Load	0.01	0.40	1	48

Table -2: Comparison of Exhaust Emissions

3. CONCLUSIONS

To use with diesel, the blends of straight diesel and algae biodiesel were prepared. The physiochemical properties of these blends were tested. It is found that:

a. Density of blend increases with blending ratio.
b. Due to higher viscosity of algae biodiesel, the viscosity of blend also increases with increase in blending ratio.
c. Algae biodiesel possesses lower calorific value than straight diesel. Because of which, calorific value of biodiesel blends also decreases with increase in blending ratio.
d. However, as cetane number of algae biodiesel is more than straight diesel. The cetane number of biodiesel blends improves with increase in blending ratio.

The blends of biodiesel were tested in VCR diesel engine. The study shows that:

a. The emissions of carbon monoxide decrease with the use of biodiesel as compared to straight diesel.
b. The emissions of carbon dioxide also decreased with use of biodiesel with the straight diesel.
c. The blending of biodiesel with diesel has minimal effect on emissions of hydrocarbon.
d. The emissions of nitrogen oxides, however, increased with increase in blending ratio.
e. All the blends show better performance at higher load and higher compression ratio.

ACKNOWLEDGEMENT

I am grateful to Mrs. SupriyaBobade and "Indian Bidiesel Corporation", Baramati for their support. I am also thankful to Head, Mechanical Engineering, Cummins College of Engineering for Women, Pune, for their assistance in this work.

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