EXPERIMENTAL STUDY ON PERFORMANCE AND EMISSIONS CHARACTERISTICS OF SINGLE CYLINDER DIESEL ENGINE BLENDED WITH MULTI VEGETABLE OILS RAPESEED AND SUNFLOWER OILS

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Abstract - *This paper investigates the performance and emission characteristics of a single cylinder diesel engine blended with multi vegetable oils diesel of rapeseed oil and sunflower oil. Different blends of these oils (B05, B10, B15, B20, and B25) have been prepared in ratio with diesel by volume for the experimental investigation. The experimental results were obtained on the performance and the emissions of CO, HC and NOx in diesel engine. Comparison of rapeseed and sunflower oil blends done with that of conventional diesel engine. The results showed that the brake thermal efficiency of the blend B20 showed improvement by 2% at high loads compared to that of diesel. The brake specific fuel consumption was slightly lesser than the diesel fuel for the blend. The CO emissions are lower than diesel by nearly 28%. The CO2 emissions for all blends were increased than conventional fuel. The HC emissions were found to be higher than diesel for almost all the blends except B20 which is reduced by 20%. However, NOx emissions of the blends were found to be increased for all the blends but for B20 which slightly lesser compared to diesel fuel.*

Key Words: **Multi Vegetable Oils, Rapeseed Oil, Sunflower Oil, Diesel, Performance and Emission Characteristics.**

1. INTRODUCTION

1.1 Alternative Fuels

The energy demand in India is increasing day by day due to the increase in population as well as increase in modernization and technology. Today our country is much dependent on petroleum reserves for satisfying all our energy demands but, we have very limited crude oil resources and we are depending on other countries for the demands. Among all the gasoline fuels available, diesel fuel is the most widely used fuel because of the more energy extraction from diesel compared with same volume of other fuels. Due to this diesel engines have many uses in heavy duty transportation power generation and also in agricultural sector. That's why diesel consumption is higher than gasoline. We all know that crude oil resources are non-renewable and so our reserve energy capacity is decreasing rapidly. All the above reasons promoted us in research of some alternative energy as a substitute for these fossil fuels. The use of vegetable oils and alcohols as an alternative fuel for diesel engines is not started today; it had been there from years back. It is not that we should use vegetable oils or alcohols as it is mentioned, truth is that the oils have some important properties like Cetane number and calorific value similar to that of diesel. Also they are inexhaustible in nature and availability can be increased depending on the demand of the fuel. All these reasons pushed us towards the vegetable oils to be used as alternative fuel. There are few operational problems related to starting ability, ignition, combustion and performance and durability problems related to deposit formation, carbonization of injection tip, ring sticking and lubrication oil dilution but, all these problems are taken care to maximum extent possible by using different methods like adding additives, piston modifications, coatings etc. Many researchers have been done using alternative fuels blending with diesel and their performance has been compared with diesel engine. But there is still lot of scope as the research for multi biodiesel blends is done less comparatively with the previous one. In this investigation combination of Rapeseed and Sunflower oil along with diesel are used as alternative fuel.

2. BIOFUEL AND METHODS

2.1. Biofuel:

The vegetable oils (Biodiesel) used in the experiment is derived from Rapeseed and Sunflower Oil Seeds which are collected from trees. Initially the oil is filtered for the removal of solid particles and then it is heated up to certain temperature for the removal of water content or moisture. In second step the oil is converted to biodiesel using transesterification process. The preheated oil is added to potassium methoxide which is obtained by dissolving potassium hydroxide catalyst in methanol. The mixture obtained is stirred in a magnetic stirrer for 2-3 hours at 60◦C.Then it is allowed to settle for 3-4 hours. After three hours we can observe the esters are formed on the top of the separation bowl and glycerol is settled at the bottom. Then esters are cleaned with 50◦C hot water for the removal of impurities. Diesel is blended with biodiesel in different proportions.

2.2 Production of Rapeseed and Sunflower Oil

Rapeseed Oil and Sunflower Oil are produced from their respective seeds by the process of cold pressing. Seeds of both plants are crushed in machine and the oil is extracted accordingly. Once the oil is obtained, it is collected, filtered, neutralized and stored.

Fig-1. Rapeseed Oil and Sunflower Oil

2.3 Trans-Esterification

Vegetable oils cannot be directly used in engines as they are highly viscous and contain high amount of free fatty acids which are very difficult to burn. Hence they are converted into methyl esters which are nothing but our bio fuels. The process of converting vegetable oils into methyl esters using methanol in the presence of strong base NaOH is called as trans-esterification. After this process the methyl esters or biofuels can be used directly or along with diesel in the engines for the experimental purpose. For our investigation the trans-esterification process is carried at SERICULTURE College, Chinthamani. The different biodiesel blends used in this investigation are specified below.

1. B05 (5% Rapeseed Oil+ 5% Sunflower Oil + 90% diesel)
2. B10 (10% Rapeseed Oil+ 10% Sunflower Oil + 80% diesel)
3. B15 (15% Rapeseed Oil+ 15% Sunflower Oil + 70% diesel)
4. B20 (20% Rapeseed Oil+ 20% Sunflower Oil + 60% diesel)
5. B25 (25% Rapeseed Oil+ 25% Sunflower Oil + 50% diesel)

Fig-2. Biodiesel production unit and collection of biodiesel

2.4 Properties of blends

The properties of the blends of bio diesel are calculated using standard ASTM methods and are noted down. Flash point and fire point are calculated using Cleveland Open Cup Apparatus, viscosity using Redwood Viscometer and calorific value using Bomb Calorimeter. The properties of different blends are shown in the tables.

Table -1: Properties of diesel and vegetable oils

Properties	Diesel	Rapeseed oil	Sunflower oil
Density (kg/m3)	845	865	860
Kinematic viscosity*10^4(m^2/s)	4.02	4.95	4.45
Calorific Value(KJ)	43450	39850	40125
Flash Point(0^c)	50	75	80
Fire Point(0^c)	58	80	84
Cetane number	52	58	56

Table -2: Properties biodiesel blends

Properties	B5	B10	B15	B20	B25
Density (kg/m3)	835	837	840	843	846
Kinematic viscosity*10^4(m^2/s)	4.15	4.18	4.13	4.1	4.1
Calorific Value(KJ)	43120	42985	41982	43052	42158
Flash Point(0^c)	54	55	58	60	62

3. EXPERIMENTAL SETUP AND PROCEDURE

3.1 Engine specifications:

The experiment was conducted on a single cylinder, 4-stroke, Compression ignition engine (Kirloskar Engine). This is a water cooled direct injection engine and the technical specifications of the engine are listed in the table below. The experimental setup is also shown in Fig. The engine was coupled to rope brake dynamometer with mechanical loading. To measure the exhaust gases like CO, HC, NOx AVL DI 444 exhaust gas analyser was used in this experiment.

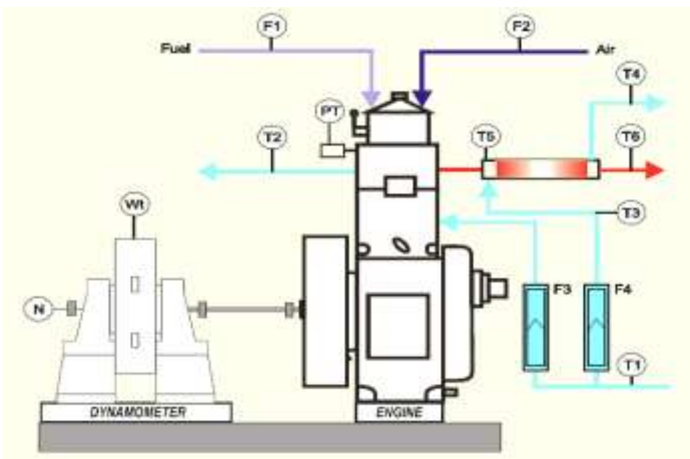

Fig-3: Line diagram of single cylinder kirloskar engine

Table-3: Engine Specifications

Engine parameters	Specifications
Engine type	4 stroke vertical
Number of cylinders	01
Rated power	3.8kw
Bore diameter	80mm
Stroke Length	110 mm
Engine speed	15000 rpm
Compression ratio	16:5:1
Type of cooling	Water cooling
Diameter of rope	0.15mm

3.1 Test Procedure:

Fuel and Lubricating oil levels are checked in the engine before starting. After that the three way cock is opened so that the fuel will flow to the engine. Cooling water is supplied to the engine through inlet pipe. Engine is started to run at rated speed and allowed to warm up for 5 minutes. Load the engine by adding the required weights to the hanger. Time taken for 10cc of fuel consumption, load on the engine, manometer reading, and speed at different loads were noted. Emission test was conducted using AVL DIGAS-444 five gas analyser.

Fig-4: AVL DIGAS-444 Gas Analyser

4. RESULTS AND DISCUSSION

4.1 PERFORMANCE CHARACTERISTICS:

A. Brake Thermal Efficiency:

The below Fig.4 shows variation of brake thermal efficiency with load for different blends of the biodiesel and diesel. It is clear from the graph that the efficiency for blend B20 (28.75%) is higher compared to B0 (Diesel) (27.25%) and is increased by 2%.At heavy loads, combustion of biodiesel blended fuels is better due to better oxygen content availability and more mass of fuel injected for equal load conditions.

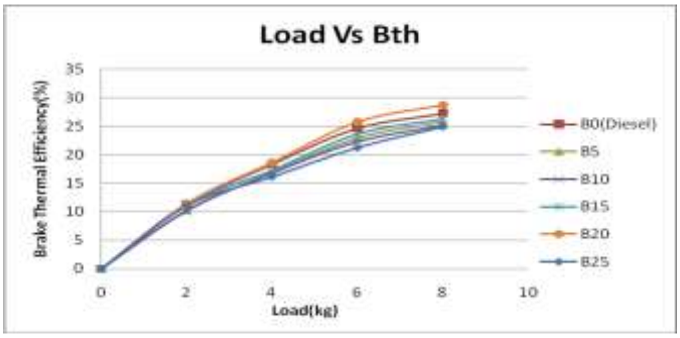

Fig-4: Comparison of brake thermal efficiency for different blends

B. Brake Specific fuel consumption:

The Fig.5 represents the variation of brake specific fuel consumption with load for different blends of the biodiesel and diesel. From the above graph it is observed that the brake specific fuel consumption is decreases with increase in load. From all the blpends B20 shows the less specific fuel consumption compare to other blends and B0 (pure diesel). The minimum brake specific fuel consumption is observed as 0.30(kg/kW-hr) for B20 blend and for pure diesel it was 0.32(kg/kW-hr). This may be to good combustion and an increase in the energy content of the blend and it may also due to lower calorific value of the blended fuel as compared with diesel.

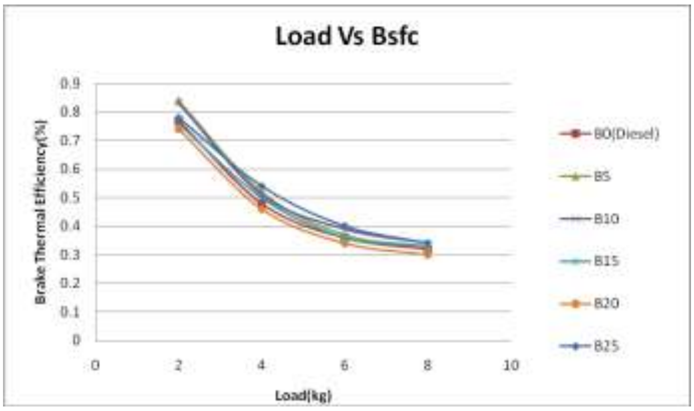

Fig-5: Comparison of brake specific fuel consumption

4.2 EMISSION PARAMETERS:

A. Hydrocarbon Emissions:

The variation of hydrocarbon emissions with the load is shown in Fig.6. The emissions for blend B20 and B15 is lower than the diesel at higher loads. The HC emissions for diesel at higher loads were 32ppm and for blends B20, B15 was 29ppm and31ppm. HC emissions for all other blends are higher than that of diesel. This can be due to incomplete combustion of the blends due to their high viscosity and poor atomization.

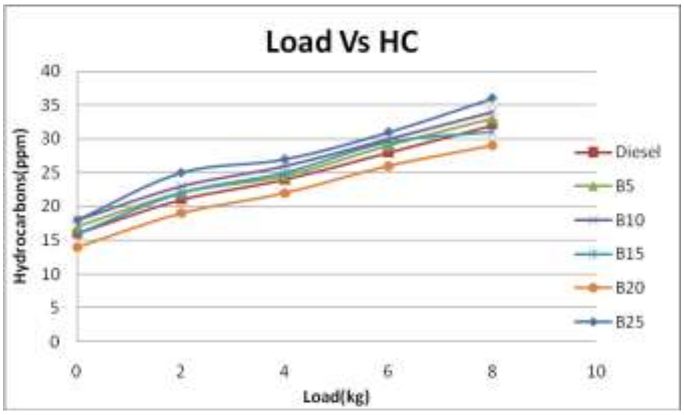

Fig-6: Comparison of Hydrocarbons

B. Carbon Monoxide Emissions (CO):

The variation of CO emissions with load for different biodiesel blends and diesel is shown in the Fig.7. Carbon monoxide is generally formed when mixture is rich in fuel. By using biodiesel CO emissions can be reduced less than the pure diesel. From the graph CO emissions of blend B20 is less than that of all other blends including diesel at high loads. The CO emissions for diesel are 0.052ppm and for blend B20 and B15 is 0.045ppm, 0.049ppm. The other blends have higher emissions compared to diesel due to poor atomization and high viscosity.

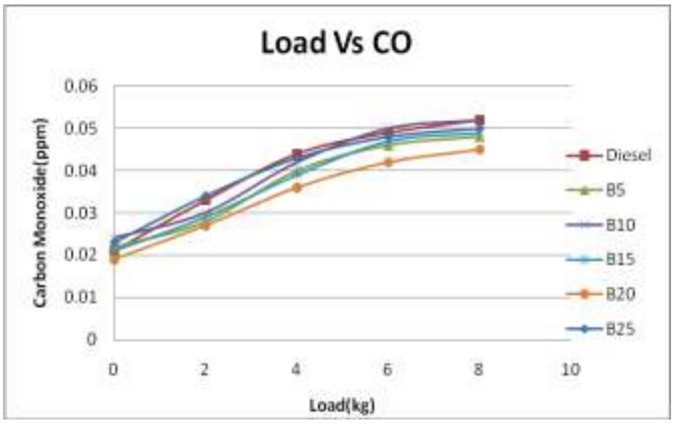

Fig-7: Comparison of Carbon Monoxides

C. Nitrogen oxide emissions (NOx):

The variation of NOx emissions with load is shown in the Fig.8. The NOX emission is produced during combustion especially at higher temperatures. From the above graph it is observed the Nitrogen Oxide emissions are increases with increase of load for all blends including diesel. In this investigation the diesel have less emission at higher loads. NOx emissions for the blend B20 have less NOx emissions at higer loads compare to other blends. The NOx emissions are 535ppm for diesel at higher loads and 538 for B20 blend. This is because of high temperatures due to rapid combustion and high oxygen content is the main conditions for formation of NOX.

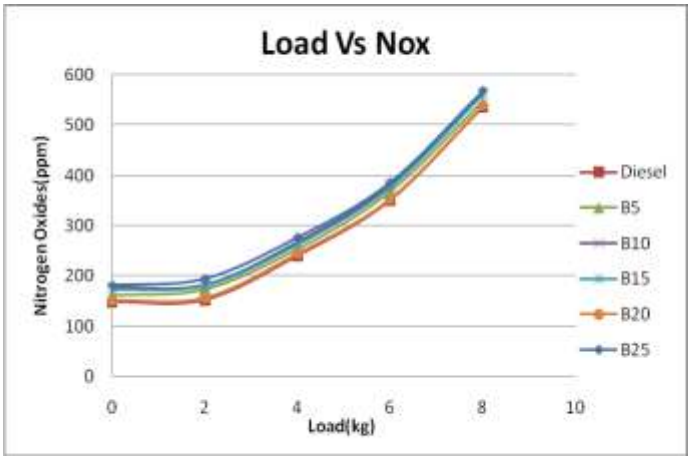

Fig-8: Comparison of Nitrogen Oxides

5. CONCLUSIONS:

Experiment had been conducted on single cylinder diesel engine (kirloskar engine) using multi vegetable oils (double blends) blends of rapeseed oil and sunflower oil with diesel and the following conclusions are drawn.

1. The properties like calorific value and kinematic viscosity of blends B20 and B15 are nearer to diesel, which is easy to storage and transportation.

2.The brake specific fuel consumption for the blends B5,B10,B15,B20,B25 has been compared with blend B0(pure diesel).The minimum brake specific fuel consumption is observed as 0.30(kg/kW-hr) for B20 blend and for blend B0(pure diesel) it was 0.32(kg/kW-hr)

3. Brake thermal efficiency for blend B20 is increased than B0 (diesel), the efficiency for blend B20 is improved by 2%.

4. The CO emissions were tested for all the blends of the biodiesel. CO emissions for the blends B20 and B15 decreases compare to B0 (Diesel).The Emissions are observed as 0.045ppm for B20 and for b15 it was0.049ppm

5. The CO2 emissions for all the blends were more than the diesel but for the blend B20 has less emissions compare to other blends.

6. HC emissions for all the blends are higher than that of diesel but for the blends B20 and B15 is lower than the B0(diesel) at higher loads,HC emissions for B20 and B15 are 29ppm ,31ppm.

7. The NOX emissions for all biodiesel blends are higher than the diesel, but for blend B20 has less emission compare to other blends and nearer to diesel.

ACKNOWLEDGEMENT:

I would like to express my sincere gratitude and thank profusely to my guide Dr.K.Hemachandra Reddy, Professor, Department of Mechanical Engineering for his wonderful support, Guidance and Suggestions for doing my project work.

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