Performance and Emission Analysis of Diesel Engine with Soyabean Oil and Diesel Blends

S.Panneerselvam[1], S.Velmurugan[2], D.Balachandar[3]
[1]Dept of Mechanical Engineering
[2,3]Assistant Professor, Dept of Mechanical Engineering
[1, 2] CK College of Engineering and Technology, Cuddalore

Abstract*- As a renewable, sustainable and alternative fuel for compression ignition engine, biodiesel instead of diesel has been increasingly fuelled to study its effects on engine performances and emissions in the recent 15 years. Biodiesel, derived from the transterification of vegetable oils or animal fats, is composed of saturated and unsaturated long-chain fatty acid alkyl esters. In spite of having some application problems, recently it is being considered as one of the most promising alternative fuels in internal combustion engine.*
The present paper investigates the use of the Soya bean oil blended with Diesel as an alternative fuel through experimental analysis of engine performance. All these are carried out on a of a compression ignition engine fuelled with various blends of biodiesel like B10, B20%, B30% and B100%, Methanol was added to improve performance and reduce emission characteristics. The best blend will be found from the analysis. Bio diesel can be used safely in Diesel engine at least in smaller blending ratio. Several engine performance tests have been carried out and initial results have been tabulated

Keywords- Alternative fuels, biodiesels, soybeans oil, etc.

I. INTRODUCTION

In recent years, a lot of effort has been taken all over the world to reduce the dependency on petroleum products for power generation and transportation. Vegetable oils and biomass-derived fuels have received much attention in the last few decades. These fuels have been found to be potential fuels for an agriculture-based country like India. Biomass is a source of fuel, which is renewable, eco-friendly and largely available. Ethanol as a bio-fuel, derived from sugarcane, has been used in gasoline engines for many years. However, bio-fuels are, in general, 3–5 times more expensive than fossil fuel.

Vegetable oils have been found to be a potential alternative to diesel. They have properties comparable to diesel and can be used to run a compression ignition engine with minor modifications. The use of vegetable oils will also reduce the net CO_2 emissions. Altin Recep et al. studied the effect of vegetable oil fuels and their methyl esters injected in a diesel engine. They observed that vegetable oils lead to problems such as gum formation, flow, atomization and high smoke and particulate emissions. Due to its complex structure and composition, gas phase emissions are higher. In order to use these fuels in diesel engines, high compression ratio and ignition assistance devices are required.

In the light of above, it becomes essential to search for alternative fuel, which can replace the petroleum products. The production of Cashew nut shell liquid is very simple and its auto-ignition properties are almost same as that of diesel fuels hence can be used in diesel engines with little or no engine modifications. Based on these facts, cashew nut shell liquid can be used as a substitute of diesel fuel.

India is the fifth largest cotton producing country in the World today, the first-four being the US, China, Russia, and Brazil. Our country produces about 8% of the World cotton. Cotton is a tropical plant.

It is a vegetable oil extracted from the soya bean, after the soya bean lint has been removed after being freed from the linters, the seeds are shelled and then crushed and pressed are treated with solvent to obtain the crude soya bean oil. Soya bean oil is one of the most widely used oil and it is relatively in-expensive and also readily available.

An objective of the present work aims to find out suitability of soya bean oil, and its blends with diesel. In this project soya bean oil and diesel blends are taken up for study on 5 HP, Single cylinder, four stroke, water cooled Kirloskar AV 1 model diesel engine and performance for different blends is tested and performance curves are drawn. Diesel either partially in the form of a blend or as a total replacement

II. EXPERIMENTAL INVESTIGATION

The experiments were conducted by considering various parameters. The tests were conducted for Diesel, soya bean and its blends at different proportions (10%, 20%, 30% and 100%) for conventional engine. The tests were conducted from no load to maximum load conditions. The readings such as time taken to consume 10 cc of fuel consumption, speed of the engine, temperatures, etc, were noted. The observations were recorded in tabular column and calculations are made using appropriate equations.

The experiments were conducted on a Single cylinder four stroke diesel engine. The general specifications of the engine are given in Table-1. By taking the engine performance and plot the graphs.

Table.1 Engine Specification

PARAMETERS	SPECIFICATION
Engine model	Kirloskar AV 1 model
Engine type	Vertical, 4 stroke cycle, single acting, High Speed CI Diesel Engine
Number of cylinders	1
Bore (mm)	80
Stroke (mm)	110
Cubic Capacity	0.553 liters
Rated speed	1500 rpm
Compression ratio	16.5:1
Dynamometer	Eddy current
Combustion	Direct injection
Governing	Class"B1"
Power rating	5 HP
Cooling system	Water
Type of load	Electrical

Table 2: Properties of Diesel, and Biodiesel

Properties	Diesel	Biodiesel
Cetane No	50	37.1
Heating Value	43.8	39.6
Flash Point	76	274
Fire Point	85	295
Density	0.855	0.9161

III. EXPERIMENTEL PROCEDURE

The raw materials involved in the reaction are sunflower oil, methanol and the catalyst (NaOH). The reaction is made in a fume cupboard.

The different steps for the biodiesel production in laboratory are:

1. Mixing of the methanol and the catalyst in a flask. The moisture level should be kept as low as possible. Water causes the formation of soap by saponification. It is necessary to reduce the formation of soap. Formation of soap consumes the catalyst is consumed and complicates the separation and purification process. Formation of soap also decreases the biodiesel yield.
2. The sunflower oil is heated to 50°C and stirred by a magnet at 800 rpm (constant speed), until, the catalyst is completely dissolved in the methanol.
3. The solution methanol-catalyst and the oil are mixed in a flask. The flask is introduced in a water bath at 50°C and stirred to 500 rpm. The reaction is performed during 15 minutes.
4. The final solution is poured into a separation funnel. The top layer is the biodiesel and the bottom darker layer is the by-product, glycerol.
5. Removal the glycerol from the biodiesel, and measure the glycerol.
6. Analysis of the properties of the produced biodiesel: density, viscosity and refractive index.
7. The experiment is repeated.

IV. EXPERIMENTAL SETUP

The experimental set up for this study is shown in Figure 1. The set up consists of single cylinder, four stroke, and variable compression ratio multi fuel engine coupled with eddy current dynamometer for loading. Engine performance analysis software package “Engine Test Express V5.76” is used for performance analysis.

The detailed specification of the engine is shown in Table 4.2. The tests have been carried out at the rated speed of 1500 rpm at different loads. Standard diesel is used to start the engine and is allowed to warm up till cooling water temperature reaches 60°C.

Then the engine operating parameters such as Brake thermal efficiency (BTE), Brake power (BP), Indicated mean effective pressure (IMEP), Specific fuel consumption (SFC), Mechanical efficiency and exhaust gas temperature with respect to different loads for different blends and for standard diesel are measured and recorded.

The exhaust emissions by combustion of biodiesel and diesel blends were measured by exhaust gas analyzer. In this analyzer the emissions Hydro carbon (HC), Carbon Monoxide (CO) and Nitrogen oxide (NOx) were recorded. With the help of smoke meter Smoke was measured.

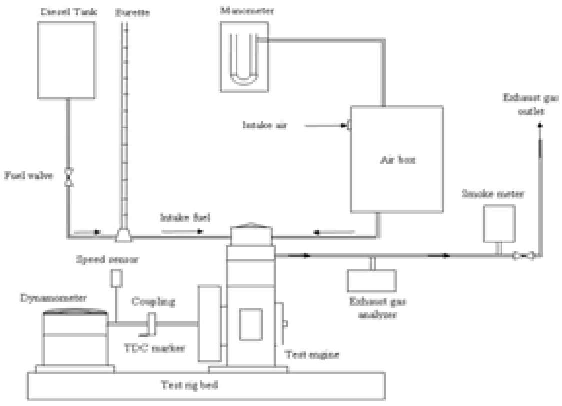

Figure 1: Experimental setup

V. EXPERIMENTAL OBSERVATION

The main objective of the test conducted was to evaluate the performance of the soya bean oil(with preheated and blended) as fuel in a diesel engine. The engine was coupled to a mechanical brake drum and the various arrangements as previously explained are prepared.

The precautions to be followed before starting the engine such as the lubricating oil,airlock (if any in the fuel line) cooling water, supply, no load condition and fuel level were checked. The speed of the engine and the rate of fuel consumption were monitored at every stage.

The inlet and outlet temperature of cooling water were noted for every load. The exhaust gas temperature was also observed at various loads. The engine was sufficiently warmed at every stage. The test set up is shown in fig. At each load brake thermal efficiency can be evaluated from Brake Power.

VARIOUS LOAD TEST

Load Test will be conducted on the 5 HP engine for the following fuels

1. With Pure High Speed Diesel
2. With B10 %preheated Soya bean oil blended diesel.
3. With B20 %preheated Soya bean oil blended diesel.
4. With B30 %preheated Soya bean oil blended diesel.
5. With B100 %preheated Soya bean oil blended diesel.

VI. PERFORMANCE & EMISSION ANALYSIS

Performance analysis includes Total Fuel Consumption, Specific Fuel Consumption, Brake Thermal Efficiency, Exhaust Gas Temperature and the emission analysis includes Nitrogen oxide, Carbon monoxide, Hydrocarbon, Smoke density.

6.1. TOTAL FUEL CONSUMPTION

Table & Figure 6.1 shows the Results of Total Fuel Consumption (Kg/hr) of various loads with Different Blends.

Table 6.1 Results of Total Fuel Consumption with various blends

LOAD %	DIESEL	B10	B20	B30	B100
0	0	0	0	0	0
25	0.531	0.659	0.645	0.631	0.449
50	0.795	1.098	0.875	0.935	0.651
75	0.981	0.916	0.981	1.082	0.792
100	1.474	1.404	1.474	2.227	1.174

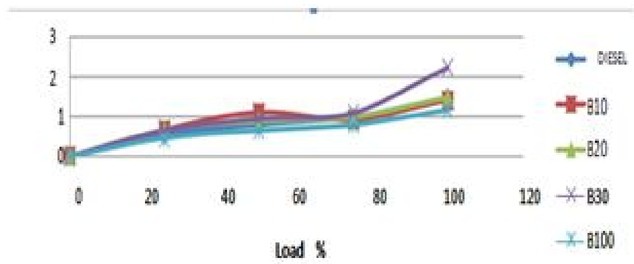

Figure 6.1 Results of Total Fuel Consumption with various blends

It can be noted from the graph TFC is higher than that of diesel at all loads this is because of low calorific values of soya bean bio diesel and its blends as compared to diesel.

6.2. SPECIFIC FUEL CONSUMPTION

Table & Figure 6.2 shows the Results of Specific Fuel Consumption (Kg/hr) of various loads with Different Blends.

Table 6.2 Results of Specific Fuel Consumption with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	0	0	0	0	0
25	0.531	0.659	0.645	0.631	0.449
50	0.795	1.098	0.875	0.935	0.651
75	0.981	0.916	0.981	1.082	0.792
100	1.474	1.404	1.474	2.227	1.174

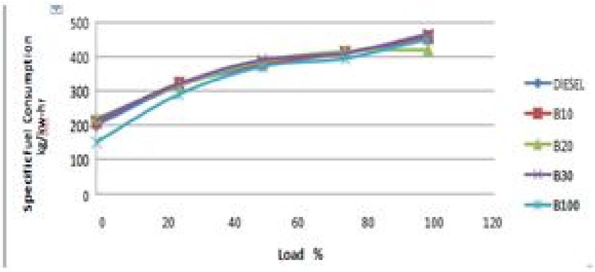

Figure 6.2 Results of Specific Fuel Consumption with various Blends

It can be noted from the graph of SFC values increases only for the higher percentage of loads. It is due to heating value, density and viscosity of the fuels.

6.3 BRAKE THERMAL EFFICIENCY

Table & Figure 6.3 shows the Results of Brake Thermal Efficiency (%) of various loads with Different Blends

Table 6.3 Results of Brake Thermal Efficiency with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	0	0	0	0	0
25	18.67	14.81	16.97	30.53	26.04
50	23.8	15.13	21.29	28.51	24.8
75	28.9	15.47	19.93	25.82	16.41
100	25.18	21.74	28.62	35.31	31.14

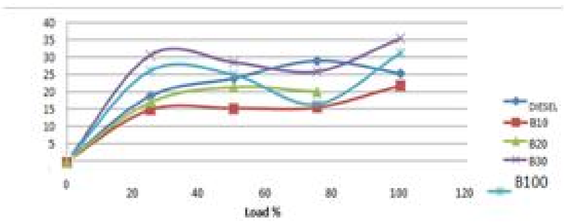

Figure 6.3 Results of Brake Thermal Efficiency with various Blends

It has been observed that when the applied load increases, the Brake thermal efficiency of the fuel also increases. The maximum brake thermal efficiency at full load is 35.31 for B30. Comparing the standard values, it is higher than 6.41% of B30.

6.4 EXHAUST GAS TEMPERATURE

Table & Figure 6.4 shows the Results of Exhaust Gas Temperature of Various loads with Different Blends.

Table 6.4 Results of Exhaust Gas Temperature with various Blends

LOAD%	DIESEL	B10	B20	B30	B100
0	190	180	165	160	250
25	290	270	220	225	335
50	384	306	275	270	410
75	420	370	342	340	440
100	540	420	440	435	620

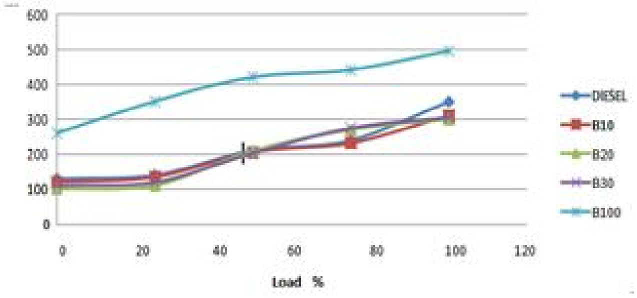

Figure 6.4 Results of Exhaust Gas Temperature with various Blends

It is observed that exhaust gas temperature increases for the biodiesel and diesel blends due to its high compression ratio. Diesel, B10, B20 and B30 have similar exhaust gas temperature and B100 is higher.

6.5 NITROGEN OXIDE

Table & Figure 6.5 shows the Results of Nitrogen Oxide of Various loads with Different Blends.

Table 6.5 Results of Nitrogen Oxide with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	200	210	220	215	150
25	315	322	315	320	290
50	375	380	385	390	370
75	410	412	415	410	395
100	450	457	420	465	450

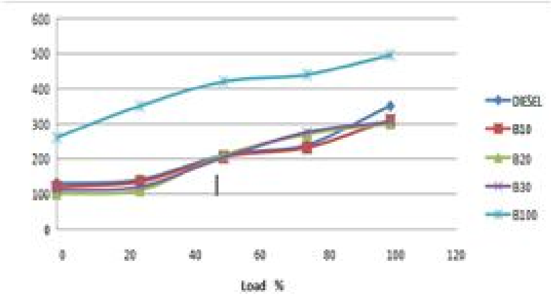

Figure 6.5 Results of Nitrogen Oxide with various Blends

From the graph it is concluded that for 100% load condition the nitrogen oxide emission from the B100 blend is higher than that of standard diesel.

6.6 HYDROCARBONS

Table & Figure 6.6 shows the Results of Hydrocarbons of Various loads with Different Blends.

Table 6.6 Results of Hydrocarbon with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	130	120	100	110	260
25	140	135	110	120	350
50	210	205	210	203	420
75	240	232	270	275	440
100	350	310	300	305	495

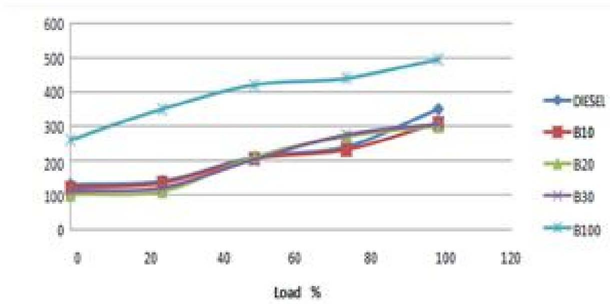

Figure 6.6 Results of Hydrocarbon with various Blends

From the graph it is concluded that for 50% load condition the hydrocarbon emission is similar for B10, B20, B30 and Standard Diesel. At 100% load condition B100 is higher than all Blends.

6.7 SMOKE DENSITY

Table & Figure 6.7 shows the Results of Smoke of Various loads with Different Blends.

Table 6.7 Results of Smoke Density with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	0	0	0	0	0
25	0.531	0.659	0.645	0.631	0.449
50	0.795	1.098	0.875	0.935	0.651
75	0.981	0.916	0.981	1.082	0.792
100	1.474	1.404	1.474	2.227	1.174

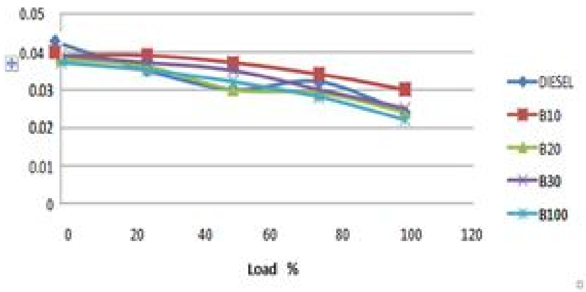

Figure 6.7 Results of Smoke Density with various Blends

It was observed that the smoke capacity of the exhaust gas increases with increase in load for all the blends. At 100 % load condition B30 produces higher percentage of smoke density compared to other blends.

6.8 CARBONMONOXIDE

Table & Figure 6.8 shows the Results of Carbon monoxide of various loads with Different Blends.

Table 6.8 Results of Carbon monoxide with various Blends

LOAD %	DIESEL	B10	B20	B30	B100
0	0.042	0.039	0.038	0.039	0.037
25	0.035	0.039	0.036	0.037	0.035
50	0.03	0.037	0.03	0.035	0.032
75	0.032	0.034	0.029	0.03	0.028
100	0.024	0.03	0.024	0.025	0.022

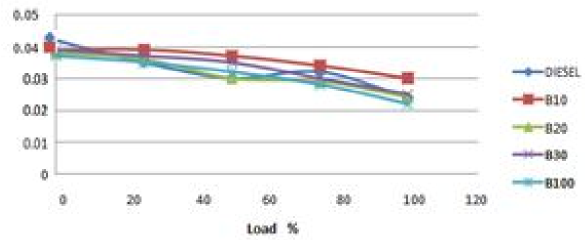

Figure 6.8 Results of Carbon monoxide with various Blends

The carbon monoxide emission of the blend B100 is found to be higher for light and medium loads and closer to that of standard diesel. Due to rising temperature in the combustion chamber, air fuel ratio, lack of oxygen at high speed, physical and chemical properties of fuel and smaller amount of time available for complete combustion, the proportion of carbon monoxide emission increases.

VII. CONCLUSION

Engine performance, combustion and emission results of blends of transesterified soya bean oil and diesel were compared with the results obtained. The following conclusions were drawn.

- From performance analysis it is observed that the performances of diesel blends are similar to diesel.
- The emission nitrogen oxide and smoke were higher than standard diesel for all blends due to their higher viscosity and density.
- As the load increases it gradually increases the exhaust gas temperature. But the mechanical efficiency increases with increase in load.
- Due to ignition delay the cylinder pressure increases for diesel at starting and for blend B20. The heat release rate is low at starting and gradually increases.
- From the performance, emission and combustion analysis of soya bean oil blends compared with standard diesel the brake thermal efficiency and specific fuel consumption are high, the combustion analysis shows that the cylinder pressure for blends are lower than diesel, emission analysis shows that smoke and nitrogen oxide increase but HC, CO decrease due to less calorific value.

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