Efficiency Improvement and Reduction in emission by using blended vegetable oil Bio-Diesel in C.I. Engine

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ABSTRACT

Bio-fuel oils are used as an alternative to diesel in CI engines with engine performance improvements and also reduce harmful exhaust gas emissions. Various blends have been reported by research in this field to be optimal, high or comparable engine performance. Bio-diesel is one of the most promising options for diesel needs. Current work focuses on the performance of castor seed oil, mustard seed oil and sunflower seed oil and for variable loads with a four cylinder, 4 stroke, naturally aspirated, direct injection, water cooled, hydraulic dynamometer diesel engine. The physical and chemical properties of castor oil, mustard oil and sunflower seed oil and its mixture were determined. Engine performance and emission characteristics were studied using castor seed oil, mustard oil and sunflower seed oil and their blends with diesel, and by analyzing performance characteristics and emission characteristics at rated load and with pure diesel to find out the best mixture by comparison of Biodiesel samples.

Keywords: Bio-Diesel, Caster seed oil, Mustard seed oil, Sunflower seed oil, CI Engine, Performance characteristics, Emission characteristics.

INTRODUCTION

Biodiesel refers to a vegetable oil or animal fat fuel based diesel fuel that contains long referenced chain alkyl (methyl, propyl, or ethyl) esters. Biodiesel is an attractive alternative to fossil fuels; It is biodegradable, non-toxic and has a low emission profile compared to petroleum fuels. Biodiesel is carbonneutral. The amount of CO2 released by burning biodiesel is the same as CO2 absorbed during the manufacture of raw materials. The use of vegetable oil in diesel engines dates back to 1892 when Rudolf Diesel demonstrated his new invention (diesel engine) using peanut (peanut) oil as a fuel. Apart from economies of scale that favored petroleum derived fuels, other factors have also hindered the use of diesel engines of great concern in diesel engines, with relatively high viscosity and low volatility of most vegetable oils and carbon deposits. All these factors have been seen to have a negative impact on engine performance. One possible measure proposed by many authors is the blending of vegetable oil and diesel in some proportions. This is expected to cut costs, improve the properties of the fuel, make it suitable for use in engines, and reduce the amount of greenhouse gases emitted into the atmosphere. Another possible solution is to modify the car engine to run pure on the B100 (100% vegetable oil). It can be expensive but one that can provide a long-term solution by preventing any conflict with food production [1].

LITERATURE SURVEY

The use of vegetable oil in diesel engines dates back to 1892 when Rudolf Diesel demonstrated his new invention (diesel engine) using peanut (peanut) oil as a fuel. In addition to economies of scale that favor petroleum derived fuels, other factors have also hindered the use of diesel engines of great concern in diesel engines due to the relatively high viscosity and low volatility of most vegetable oils and carbon during pistons are credited. Engine running [2].

Biodiesel can be legally mixed with petroleum diesel in any percentage. ASTM International develops specifications for conventional diesel fuel (ASTM D 975). These specifications allow for biodiesel concentrations of up to 5% (B5). ASTM approved for safe operation in any compression-ignition engine operating on low-level biodiesel blends, such as B5 petroleum diesel. Biodiesel is mixed in many different concentrations, including B100 (pure biodiesel), B20 (20% biodiesel, 80% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel) and B2 (2% biodiesel), and 98% may be used Petroleum Diesel [3] [5].

MATERIAL & METHODS

This describes the methodology used for standardization of methyl transesterification process parameters for Castor oil, Mustard oil and Sunflower oil. It describes the characteristic fuel properties and experimental procedure adopted to calculate the properties of nine different fuel blends and select the optimum blend based on these properties. The experiments of Transesterification of oils were conducted in Chemistry Laboratory (Humanities and Applied Science Department) in ARMIET, Sapgoan. The parameters studied and methodologies adopted are discussed in this chapter.

A. Materials Required

- 1 liter of Vegetable Oil
- 1 liter Mixture of Castor seed oil (500 ml) & Mustard Seed oil (500 ml).
- 1 liter Mixture of Castor seed oil (500 ml) & Sunflower oil (500 ml).
- 1 liter Mixture of Sunflower oil (500 ml) & Mustard Seed oil (500 ml).
- NaOH (caustic soda), at least 6g. This is often used as a drain cleaner and can often be found in local supermarket.
- Methanol (at least 250ml).Used as an Antifreeze, can often we found in Motor supply shops.

B. Equipment Required

- 1 to 2 liter Plastic Bottle
- Measuring cup
- Measuring scale
- Container to mix the methanol and NaOH (methoxide) not plastic.
- Funnel

C. Making of Methoxide

- 250ml of Methanol taken and added 4g (about half a Teaspoon) NaOH.
- Methanol and NaOH does not easily mix. Started mixing with the help of Magnetic stirrer, kept methanol at body temp (not warm).
- It will need to ensure all the NaOH is dissolved in the Methanol, this could take over ten minutes.

D. Making of Biodiesel

- The temperature of vegetable oil increased up to 70 deg C on burner.
- When the Oil temperature has dropped to 60 deg C or less, using funnel, poured the liter of oil into dry plastic container. Methanol/NaOH (Methoxide) taken and added to the oil. Ensured that the container is sealed securely then shaked vigorously for about 15 seconds.
- Leaved Biodiesel to set. It was noticed that after about 10 minutes the glycerin or soap was settle from mixture. It was took 12 hours for the Biodiesel to completely separate. After it was seen two defined layers – the Biodiesel and the glycerin. Typically the glycerin layer is about the same or a bit more than the amount of methanol used.
- After 12 hours removed the Biodiesel from the container, the glycerin was separated and make ready for the washing.

E. Washing Biodiesel

- The glycerin or soap and water was separated the impurities from Biodiesel. Violently shaked unwashed Biodiesel as it will form an emulsion that was taken a day to fully separate. The gentle approach was needed.
- Pour 1 liter biodiesel into a clean and dry plastic bottle. Gently pour in 500ml water (body temp).
- Replaced bottle top.
- Gently rotated the bottle end for about 30 seconds.
- After 30 seconds placed bottle upright.
- It noticed that the water is not clear.
- Removed top and using thumb as a stopper, turn bottle upside-down and drained the water using thumb as a valve.

F. Blending of Biodiesel and Diesel Mixture

- Biodiesel samples were prepared with combination of two vegetable oil from Castor oil, Mustard oil and Sunflower; i.e. combination of, i) Castor oil and Mustard oil ii) Mustard oil and Sunflower oil iii) Castor oil and Sunflower oil.
- Biodiesel samples prepared from 3 vegetable oils has been blended in regular diesel with different proportions by using Magnetic stirrer.
- Biodiesel and Diesel mixture samples prepared with following different proportions,

EXPERIMENTAL SETUP

The different equipment's and setup which is required for experiment is shown in the Figure 1,

Figure 1 Actual Experimental Setup

A. Engine Specification

Engine specification of the engine which is used for this project work is specified below,

TABLE I. Engine Specifications

Manufacturer	Microtech Engineering
Engine type	Four stroke, four cylinder, Vertical, Water cooled Diesel engine International B275
B.H.P.	20 B.H.P.
Speed (R.P.M.)	2000

Firing order	1-3-2-4
Dynamometer	Hydraulic Dynamometer

The prepared biodiesel from Sunflower oil, Castor seed oil and Mustard seed oil was blend with diesel in 3 different proportions i.e. 5%, 10% and 15% to prepare its blends i.e. B05D95, B10D90 and B15D85.

Different properties of blended Biodiesel samples was determined with standard measuring instruments which are showed in TABLE II,

TABLE II. Standard measuring instrument used to determine blended biodiesel samples properties

Sr. No.	Properties	Measuring Instrument
1	Kinematic Viscosity	Ostwald's Viscometer
2	Specific Gravity	Specific Gravity bottle
3	Flash point and Fire point	Abel's Flash point/ Fire point Apparatus
4	Cetane Number	Ignition Quality Tester
5	Calorific Value	Bomb Calorimeter

In TABLE IV shows the different properties of blended samples which determined with standard measuring instruments which are showed in TABLE III,

TABLE III. Different properties of Blended Biodiesel Samples

Samples	Viscosity Poise (Mm2/Sec) At 32 0c	Specific Gravity (G/Ml)	Flash Point (0c)	Fire Point (0c)	Cetane No	Calorific Value (Kj/Kg)
S+C B05d95	2.2059	0.816	49	68	50	39500
S+C B10d90	2.2923	0.824	45	68	50.6	39334
S+C B15d85	2.467	0.831	39	64	51	39250
C+M B05d95	2.2681	0.827	54	67	50	41754
C+M B10d90	2.3148	0.838	52	66	50.4	41631
C+M B15d85	2.4483	0.857	49	62	51	41508
S+M B05d95	2.1099	0.813	43	60	52	41435
S+M B10d90	2.1551	0.815	44	62	52.5	41300
S+M B15d85	2.3652	0.824	40	54	53	41225

RESULT AND DISCUSSION

A. Biodiesel Properties

i. Viscosity

This is seen by comparing the viscosity of different samples of mixed biodiesel, with diesel viscosity increasing the blending percentage of biodiesel. Diesel had an increased viscosity value compared to diesel at 15% blending of biodiesel (S + C, C + M, and S + M). Compared to other mixtures, sunflower and mustard oil blended biodiesel has lower viscosity.

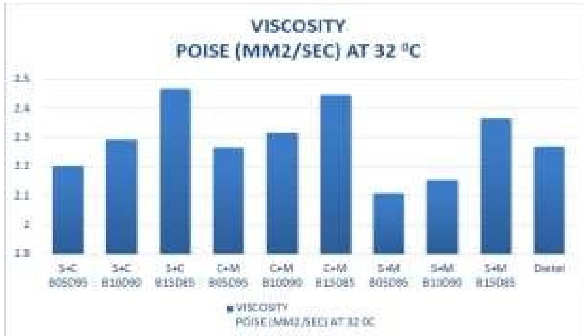

Figure 2 Viscosity of different Biodiesel blends.

ii. Specific Gravity

This is seen from the comparison of specific gravity of different biodiesel mixtures, the change in the values of specific gravity according to the mixtures shown in Fig. 3. It is observed from this graph that C + M (B15D85) has the highest value of specific gravity, while S + M (D05D95) has the lowest value, with the remainder between these two values.

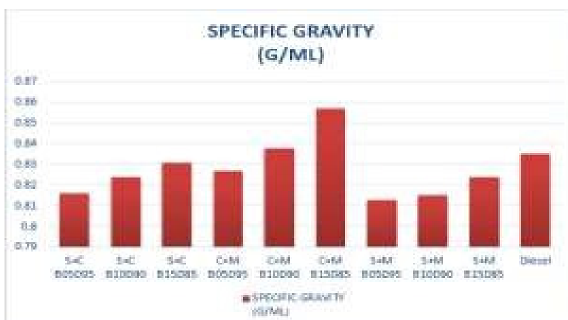

Figure 3 Specific Gravity of different Biodiesel blends.

iii. Flash Point and Fire Point

It is observed from comparison of values of flash point and fire point, Sunflower and Mustard oil blend having average as compared to other blends and closer to Diesel. The values of flash point and fire point temperature in 0C shown in below graph, Figure 4,

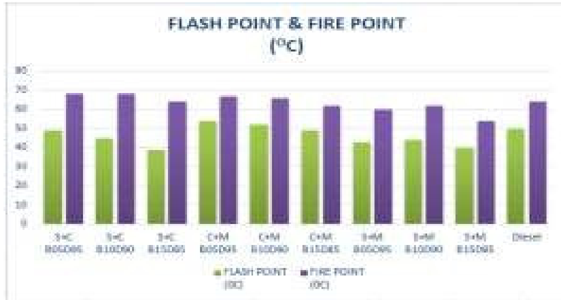

Figure 4 Flash point and Fire point of different Biodiesel blends.

iv. Cetane Number

Different values of Cetane Number of different blends of biodiesel was observed from different blending percentage of Biodiesel in Diesel. From this comparison cetane value of Sunflower and Mustard oil blend is higher, which is good ignition quality of fuel. Comparison is shown in Figure 5,

Figure 5 Flash point and Fire point temperature of different Biodiesel blends.

v. Calorific Value

It is observed from comparison of Calorific value of different biodiesel blends, the S+C is having lowest calorific value while C+M & S+M having calorific value closer to diesel. The comparison of Calorific values for blends shown in Figure 6,

Figure 6 Calorific values of different Biodiesel blends.

B. Engine Performance

After comparison of different properties of 9 Biodiesel blends, the best one selected for testing on Diesel Engine [8] - Sunflower + Mustared oil Biodiesel Blend. 1. Performance Characteristics

i. Diesel Sample

TABLE IV. Performance characteristics of diesel sample

Load (kg)	Engine Speed (rpm)	Time (sec)	Ex. temp. (°c)	Fuel consumption (Kg/hr.)	Brake power (Kw)	Brake sp. Fuel consumption (Kg/Kw hr.)	Thermal Efficiency (%)
0	1500	74	260	0.81	0	0	0
5	1500	54	310	1.11	1.34	0.828	9.3
10	1500	45	340	1.33	2.7	0.492	15.7
15	1500	39	390	1.53	4.04	0.379	20.4
20	1500	33	420	1.81	5.39	0.336	23
25	1500	27	450	2.21	6.74	0.328	23.6

ii. S+M – B05D95 Blended Biodiesel Sample

TABLE V. Performance characteristics of s+m – b05d95 sample

Load (kg)	Engine Speed (rpm)	Time (sec)	Ex. temp. (°c)	Fuel consumption (Kg/hr.)	Brake power (Kw)	Brake sp. Fuel consumption (Kg/Kw hr.)	Thermal Efficiency (%)
0	1500	69.52	270	0.85	0	0	0
5	1500	52.9	315	1.12	1.347	0.8314	10.14
10	1500	42.71	360	1.39	2.695	0.519	16.32
15	1500	37.31	400	1.59	4.04	0.378	21.4
20	1500	31.46	450	1.89	5.39	0.35	24.05
25	1500	25.87	470	2.3	6.73	0.34	24.71

iii. S+M – B10D90 Blended Biodiesel Sample

TABLE VI. Performance characteristics of s+m – b10d90 sample

Load (kg)	Engine Speed (rpm)	Time (sec)	Ex. temp (°c)	Fuel consumption (Kg/hr.)	Brake power (Kw)	Brake sp. Fuel consumption (Kg/Kw hr.)	Thermal Efficiency (%)
0	1500	67.8	275	0.87	0	0	0
5	1500	48.4	320	1.23	1.347	0.91	9.26
10	1500	40.23	365	1.48	2.695	0.549	15.4
15	1500	34.23	410	1.74	4.04	0.43	19.64
20	1500	28.67	460	2.07	5.39	0.384	21.8
25	1500	23.53	475	2.53	6.73	0.375	22.51

iv. S+M – B15D85 Blended Biodiesel Sample

TABLE VII. Performance characteristics of s+m – b15d85 sample

Load (kg)	Engine Speed (rpm)	Time (sec)	Ex. temp (°c)	Fuel consumption (Kg/hr.)	Brake power (Kw)	Brake sp. Fuel consumption (Kg/Kw hr.)	Thermal Efficiency (%)
0	1500	66.63	280	0.91	0	0	0
5	1500	47.48	330	1.287	1.347	0.95	8.92
10	1500	40.25	375	1.56	2.695	0.57	14.72
15	1500	33.3	420	1.83	4.04	0.45	18.82
20	1500	27.38	465	2.14	5.39	0.39	21.41
25	1500	22.42	490	2.62	6.73	0.38	21.91

The different Results are plotted as per the readings taken on diesel engine for different testing parameters,
a. BSFC Vs BP

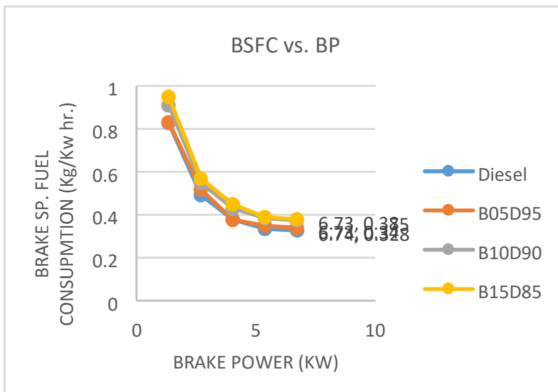

Figure 7 BSFC Vs BP graph

From BSFC Vs BP graph, it is observed that, Break specific fuel consumption of B05D95 blending of Sunflower and Mustard oil biodiesel blend is lower as compared to other blends (B10D90 and B15D95) for specific speed (1500 rpm).

b. Thermal Efficiency (%) Vs BP

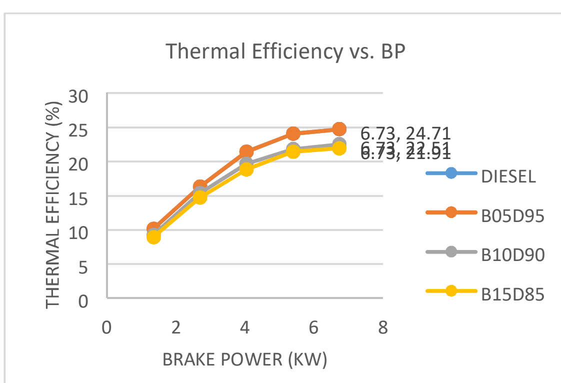

Figure 8 Thermal Efficiency Vs BP graph

It is observed From Thermal Efficiency Vs BP graph that, Thermal Efficiency of B05D95 blending of Sunflower and Mustard oil blend is more as compared to other blends (B15D85 and B10D90) and pure Diesel for specific speed (1500 rpm).

c. Exhaust Gas Temperature Vs BP

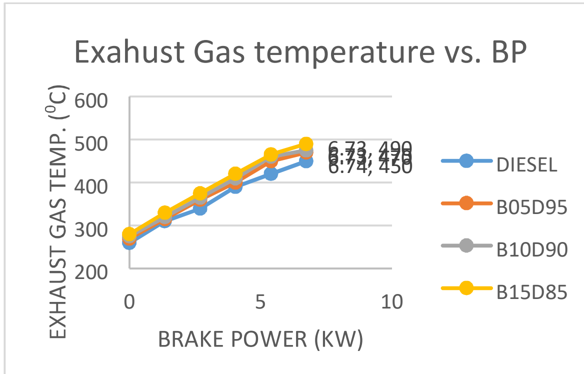

Figure 9 Exhaust gas temperature Vs BP graph

From Exhaust gas temperature Vs BP graph (Figure 6.8) observed that, Exhaust gas temperature of B05D95 blending of Sunflower and Mustard oil biodiesel blend is lower as compared to other blends (B10D90 and B15D95) for specific speed (1500 rpm).

2. Emission Characteristics

The emission characteristics for S+M biodiesel blends and diesel are taken by testing on Exhaust gas analyzer on Diesel engine.

i. Diesel

TABLE VIII. Emission characteristics of diesel sample

LOAD	HC	CO	NOX
0	22	0.01	3
5	18	0.05	3
10	13	0.1	4
15	11	0.17	7
20	8	0.22	15
25	6	1.6	38

ii. S+M – B05D95 Blended Biodiesel Sample

TABLE IX. Emission characteristics of s+m – b05d95 sample

LOAD	HC	CO	NOX
0	19	0.01	4
5	17	0.06	5
10	11	0.11	7
15	9	0.18	11
20	7	0.24	17
25	5	1.8	40

iii. S+M – B10D90 Blended Biodiesel Sample

TABLE X. Emission characteristics of s+m – b10d90 sample

LOAD	HC	CO	NOX
0	18	0.05	6
5	15	0.09	8
10	11	0.15	12
15	9	0.21	19
20	7	0.28	27
25	5	2.3	43

iv. S+M – B15D85 Blended Biodiesel Sample

TABLE XI. Emission characteristics of s+m – b15d85 sample

LOAD	HC	CO	NOX
0	16	0.07	9
5	14	0.12	11
10	7	0.18	14
15	5	0.23	20
20	4	0.31	32
25	2	2.9	48

The graphs of NOx, HC and CO for S+M biodiesel blend and Diesel are plotted as per result tables of Emission characteristics (TABLE VIII to TABLE XI),

a. NOx Vs Load

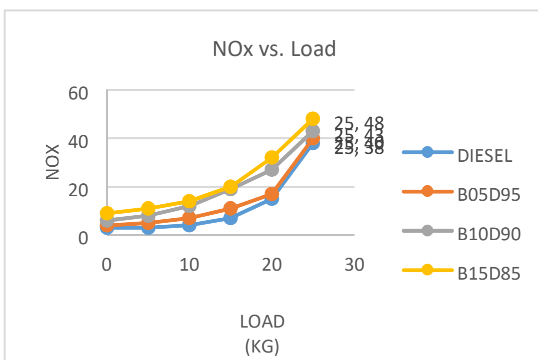

Figure 10 NOx Vs Load graph

The Figure 6.9 shows NOx Vs Load graph for different S+M biodiesel blend and diesel. As vegetable oils have larger value of O2 than diesel so oil burns more inside the cylinder which leads larger value of temperature inside the cylinder which is the main cause of the larger value of NOx in case of B15D85 biodiesel blend of S+M oil blend and S+M (B05D95) having lower values of NOx as compared to other blends.

b. HC Vs Load

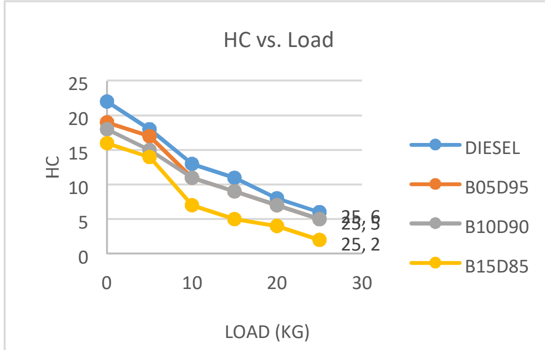

Figure 11 HC Vs Load graph

Larger the value of oxygen, lesser will be the HC percentage. As the Sunflower and Mustard vegetable oil contents larger oxygen amount, so they emit less hydrocarbon. Growing percentage of blend leads to decrease in hydrocarbon. It observed that, S+M (B15D85) having lower value of HC as compared to other blends (B05D95, B10D90) and Diesel.

c. CO Vs Load

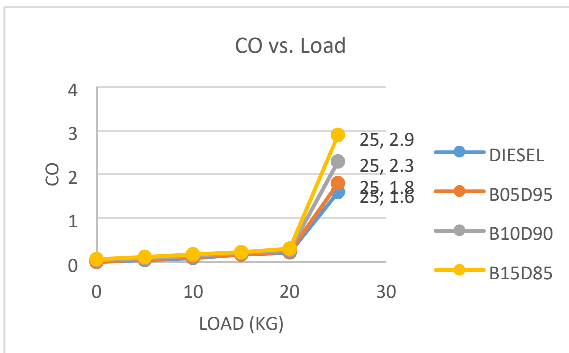

Figure 12 CO Vs Load graph

Vegetable oil contains larger value of oxygen than diesel, which acts as a combustion promoter in the cylinder. When load increased upto 20 kg. then more power was required to attain specific speed (1500 rpm) so, the incomplete combustion takes place and we got more CO % in S+M (B15D85) biodiesel blend as compared to other S+M biodiesel blends and Diesel.

CONCLUSIONS

1. The Engine performance readings (BSFC Vs BP, Thermal Efficiency Vs BP and Exhaust gas temperature Vs BP) and Emission characteristics (NOx, HC and CO) for S+M B05D95 biodiesel blend gives optimum value as compared to other blends (B10D90 and B15D85) and pure diesel.
2. The S+M B05D95 biodiesel blend has minimal values of CO, NOx than other S+M biodiesel blends. This is due to better combustion of S+M B05D95 fuel inside the diesel engine cylinder.
3. The properties like density, viscosity, flash point of blends is higher and calorific value is almost closer to that of diesel.
4. As the graphs (Engine performance and Emission characteristics) shown that 5% blending of S+M biodiesel blend gives better performance on Diesel engine other than 10% and 15 % S+M biodiesel blends in pure diesel.
5. 5 % Biodiesel mixing of S+M oil with diesel improves most of the fuel properties and can be used as an alternative fuel for diesel engines.

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