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Performance Analysis and Emission Characteristics of Palm Based Biodiesel Blends on Single Cylinder Four Stroke VCR Engine

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Abstract: Biodiesel is one of the hottest topics among people who are studying on alternate sources of energy. Its renewability as well as sustainability enforces people to identify more and more on its applicability. Various oils based biodiesel has been studied so far on various engines but the study that this paper deals with haven't yet been produced anywhere. This paper deals with study of Palm oil based biodiesel and its varying blends with petro-diesel on Single Cylinder Four Stroke VCR Engine. The study shows the effect of fuel combustion as a function of its emission characteristics, engine efficiency and fuel capacity.

Keywords — Palm Biodiesel, VCR Engine, Emission Characteristic, Four stoke,

I. INTRODUCTION

It is observed that the consumption of diesel is increasing day by day and the production has limitation. Sooner or later the quantity of diesel will become the problem. It was necessary to find out the alternative source for diesel. With decrease in the oil reservoirs quantity and increase in environmental pollution, it is mandatory to find out the alternate source for the energy generation through fuel energy [1–3]. For diesel, as it is used in internal combustion engine, the potential alternative source is Biodiesel. The mixture of methyl esters with long chain fatty acids commonly known as the biodiesel made up from vegetable oils or animal fats. For current study we have considered Palm based biodiesel[2,4]. The closed carbon cycle is the biggest advantage of biofuels. But as biodiesel is higher viscous and having higher density compared to petro-diesel, the current internal combustion engine is not suitable for it. To overcome this disadvantage, it is advisable to blend biodiesel to the petro-diesel[5].

The most practical approach to take care of the developing vitality demand for transportation fuels with no expansion in the ozone-harming substance emissions i.e. Green House Gases is by using alternative fuels. Palm oil (PO) is one of those alternative fuels. Its physical and chemical properties are near diesel. Be that as it may, because of its high viscosity, its immediate use as fuel in diesel motors prompt a poor atomization, carbon stores or creates hindrance in fuel lines. In order to reduce the viscosity of Palm Oil, methods such as blending biodiesel with diesel and/or alcohols, preheating, trans-esterification or the use of additives (solvents) are suggested in the past. [6,7] Earlier study on identification Cetane Number using Palm Based Biodiesel and Petro-Diesel Blends has been already done. [8] Also, the study of physic-chemical properties for Palm oil biodiesel and petro-diesel blend also provides a basis for this study. [9]

The current study is objected to analyse the performance of Palm Based Biodiesel – Diesel blends on Single Cylinder Four Stroke Vapour Compression Recycle Engine, the specifications of engine are given in table 1. Further, the properties of Palm Oil are enlisted in table 2.

Table 1: Engine Specifications

Parameters	**Value/Units**
Company, Model	Kirloskar – AV1
Bore	80 mm
Stroke	110 mm
Volume	553 cc
Rated Power Output	5HP at 1500 RPM
Cooling System	Water cooled
Compression ratio	16.5:1

Table 2: Properties of palm oil [10,11]

Properties	**Values**
Melting point (^{0}C)	34.2
Specific Gravity	0.89 - 0.92
Refractive Index	1.46
Iodine Value	47 - 55.83
Saponification value (mg KOH/g)	196 - 208.2
Unsaponifiable matter (%)	0.01 - 0.5
Moisture and impurities (%)	0.1
Free Fatty Acid Analysis	
C12:0	0.1
C14:0	1.0
C16:0	44.7
C16:1	0.1
C18:0	4.0
C18:1	40.1
C18:2	9.5
C18:3	0.2
C20:0	0.2

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II. EXPERIMENTAL PROCEDURE

The step by step experimental procedure is represented below for performance and emission testing; the pictorial representation of the experimental setup is shown in figure 1.

1. Ensure that sufficient fuel is available in fuel tank.
2. Give 230 V A.C. supplies to the trainer by connecting the three-pin top provided with the trainer to the distribution board in your laboratory. Switch on the supply.
3. Provide cooling water to engine, dynamometer and exhaust gas calorimeter.
4. Switch ON mains switch mounted on electrical console. Ensure that all indicators are displaying readings.
5. Open the fuel supply valve of engine.
6. Connect the cable between card and connector block.
7. Start the computer. Wait up to ICON base screen occurs.
8. Now select the performance test and read procedure.
9. Run the software in AUTO mode. Perform the experiments with help of procedure.
10. Start the engine and run the engine in idle about 30 minutes.
11. Run the engine at 1500 rpm under no load condition. Let the engine stabilize.
12. Observe that fuel-high blink once; wait till fuel low blink once than store readings by clicking on STORE button.
13. Start AVL gas analyzer with main switch.
14. Perform leak check in exhaust probe with gas analyzer and make sure that low pressure in exhaust is stable.
15. Insert exhaust probe at the end of engine exhaust manifold at time of measurement of exhaust gases.
16. Check reading on gas analyzer screen and wait till it becomes stable become, after that store the reading of CO, NO_X, CO_2, O_2, smoke opacity and equivalence ratio.
17. Remove the exhaust probe from exhaust manifold.
18. Load the engine using handle provided on the dynamometer.
19. Note down readings as per observation table
20. Load the engine up to its maximum capacity in AUTO/MANUAL mode
    a. In manual mode, first put the toggle switch in manual mode and load the engine by increasing current through the eddy current control panel.
    b. In AUTO mode, first put the toggle switch in AUTO mode and load the engine by increasing the current through computer.
21. Store the readings from 0% to 100% load following above procedure.
22. Click on END button for completing observations and going to observation result table.
23. Click on PRINT TABLES button for printing the observation and result tables.
24. Click on graph of individual experiments for plotting graphs.
25. Click on CALCULATIONS button for observing calculation procedure.
26. Click on EXIT button to stop the experimentation.
27. Now stop the engine using cut off switch.
28. Now untighten the screws on the side of the head. Then by rotating the lead screw on auxiliary head increase the clearance volume.
29. Note down the reading of pointer attached to hand wheel.

Repeat the procedure explained earlier and take readings at different clearance volume. After varying the compression ratio load the engine till its RPM drops below 1500 RPM.

FIGURE 1: EXPERIMENTAL SETUP

The exhaust gas emissions were studied using an AVL exhaust emission analyzer; the set up of the same is shown in figure 2.

FIGURE 2: AVL EXHAUST GAS ANALYZER

III. RESULT AND DISCUSSION

3.1 Engine Performance:

The engine performance is usually studied on the following variables keeping load as set variable:

(a). Time to inject 20 ml Fuel in seconds

(b). RPM

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(c). Brake Power in kW
(d). Fuel Consumption in gm/s
(e). Brake Thermal Efficiency (%)
(f). Specific Fuel Consumption in kg/kWh

The effect of pure diesel is given in table 3. Engine performance for 5% Palm Biodiesel and 95% Diesel is shown in table 4. Engine performance for 10% Palm Biodiesel and 90% Diesel is shown in table 5. Engine performance for 15% Palm Biodiesel and 75% Diesel is shown in table 6. Engine performance for 20% Palm Biodiesel and 80% Diesel is shown in table 7. Engine performance for 25% Palm Biodiesel and 75% Diesel is shown in table 8. Engine performance for 30% Palm Biodiesel and 70% Diesel is shown in table 9.

Table 3: Engine Performance for pure diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	141	1567	0.209	0.072	6.7	1.238
20	128	1541	0.359	0.084	9.8	0.845
40	106	1530	0.842	0.112	17.3	0.480
60	76	1526	1.759	0.176	23.1	0.361
80	58	1490	2.810	0.247	26.3	0.316
100	47	1440	3.885	0.316	28.4	0.293

Table 4: Engine Performance for 5% PB and 95% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	124	1567	0.209	0.089	5.5	1.525
20	118	1541	0.359	0.096	8.7	0.960
40	97	1530	0.842	0.127	15.3	0.545
60	71	1526	1.759	0.192	21.1	0.393
80	56	1490	2.810	0.257	25.3	0.329
100	46	1440	3.885	0.324	27.7	0.300

Table 5: Engine Performance For 10% PB And 90% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	123	1567	0.209	0.090	5.5	1.545
20	118	1541	0.359	0.096	8.8	0.960
40	98	1530	0.842	0.126	15.7	0.537
60	69	1526	1.759	0.199	20.7	0.408
80	52	1490	2.810	0.281	23.5	0.360
100	41	1440	3.885	0.370	24.7	0.342

Table 6: Engine Performance For 15% Pb And 85% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	124	1567	0.209	0.089	5.7	1.525
20	123	1541	0.359	0.090	9.6	0.900
40	92	1530	0.842	0.137	14.8	0.586
60	72	1526	1.759	0.189	22.3	0.387
80	52	1490	2.810	0.281	24.0	0.360
100	42	1440	3.885	0.360	25.9	0.333

Table 7: Engine Performance For 20% Pb And 80% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	133	1567	0.209	0.079	6.4	1.364
20	127	1541	0.359	0.085	10.2	0.856
40	107	1530	0.842	0.111	18.5	0.474
60	76	1526	1.759	0.176	24.2	0.361
80	58	1490	2.810	0.247	27.7	0.316
100	46	1440	3.885	0.324	29.1	0.300

Table 8: Engine Performance For 25% Pb And 75% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	128	1567	0.209	0.084	6.1	1.451
20	111	1541	0.359	0.105	8.4	1.052
40	88	1530	0.842	0.145	14.2	0.622
60	68	1526	1.759	0.203	21.3	0.415
80	52	1490	2.810	0.281	24.6	0.360
100	42	1440	3.885	0.360	26.5	0.333

Table 9: Engine Performance For 30% Pb And 70% Diesel

% load	Time to inject 20 ml Fuel (s)	RPM	Brake Power (kW)	Fuel Consumption (gm/s)	BTE (%)	SFC (kg/kWh)
0	134	1567	0.209	0.078	6.6	1.347
20	118	1541	0.359	0.096	9.3	0.960
40	95	1530	0.842	0.131	15.9	0.561
60	69	1526	1.759	0.199	21.9	0.408
80	51	1490	2.810	0.287	24.3	0.368
100	40	1440	3.885	0.380	25.4	0.352

The effect of varying fractions of biodiesel in diesel blends on Nitrous oxide (NOx) emissions and Carbon Monoxide (CO) emissions is given in table 10.

Table 10: NO_x and CO Emission for Various Biodiesel Percentages

Fuel Type	Load (%)	0	20	40	60	80	100
	Brake Power (kWh)	0.209	0.359	0.842	1.759	2.81	3.885
Pure Diesel	NO_x (ppm)	36	58	118	198	328	555
	CO (%)	0.13	0.108	0.101	0.092	0.084	0.075
B05	NO_x (ppm)	38	63	126	218	364	570
	CO (%)	0.125	0.106	0.099	0.089	0.082	0.075
B10	NO_x (ppm)	51	75	138	231	425	621
	CO (%)	0.12	0.104	0.098	0.088	0.08	0.074
B15	NO_x (ppm)	52	77	139	236	430	654
	CO (%)	0.113	0.101	0.096	0.084	0.078	0.072
B20	NO_x (ppm)	56	81	141	241	438	688
	CO (%)	0.11	0.098	0.092	0.08	0.074	0.07
B25	NO_x (ppm)	61	87	148	252	451	705
	CO (%)	0.106	0.095	0.09	0.074	0.069	0.065
B30	NO_x (ppm)	68	92	154	260	460	710
	CO (%)	0.104	0.092	0.085	0.071	0.066	0.06

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The effect of Brake Thermal Efficiency with change in Brake Power is shown in figure 3 and that of Specific Consumption fuel is shown in figure 4.

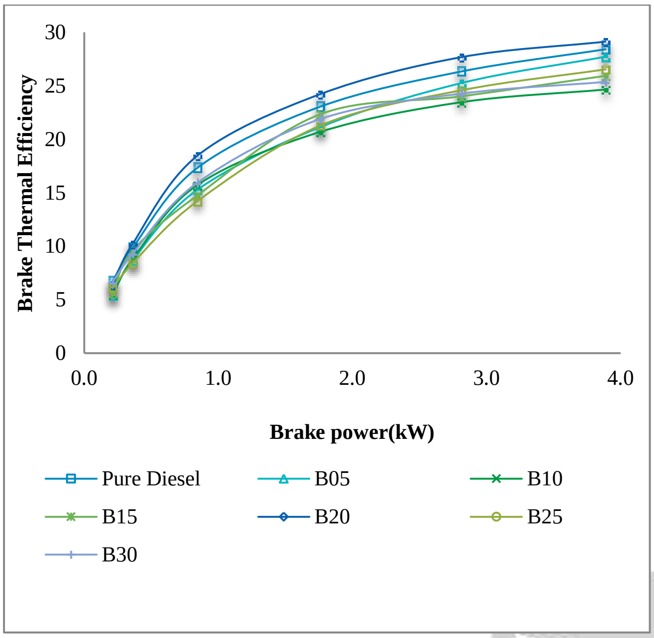

Figure 2: Brake Thermal Efficiency versus Brake Power for various Blend Percentages

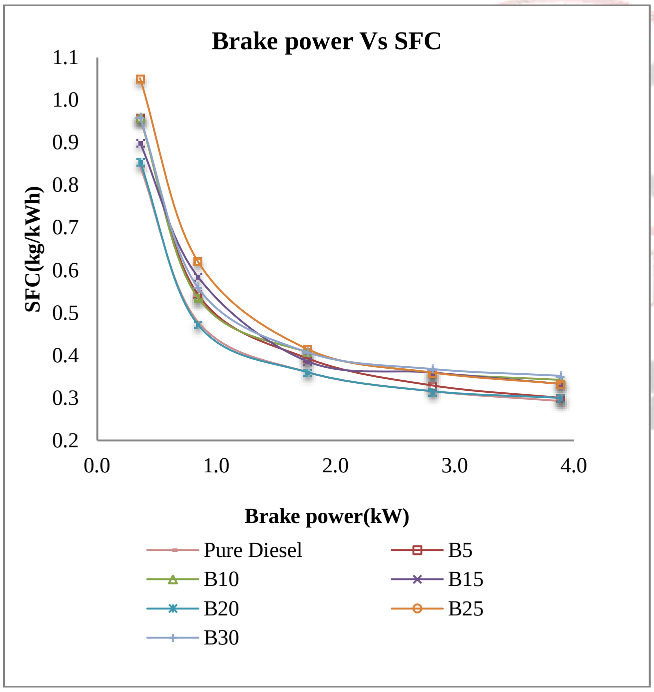

Figure 3: Specific Fuel Consumption versus brake power for Various Blend Percentages

The NOx and CO emission effects are given in figure 5 and 6 respectively.

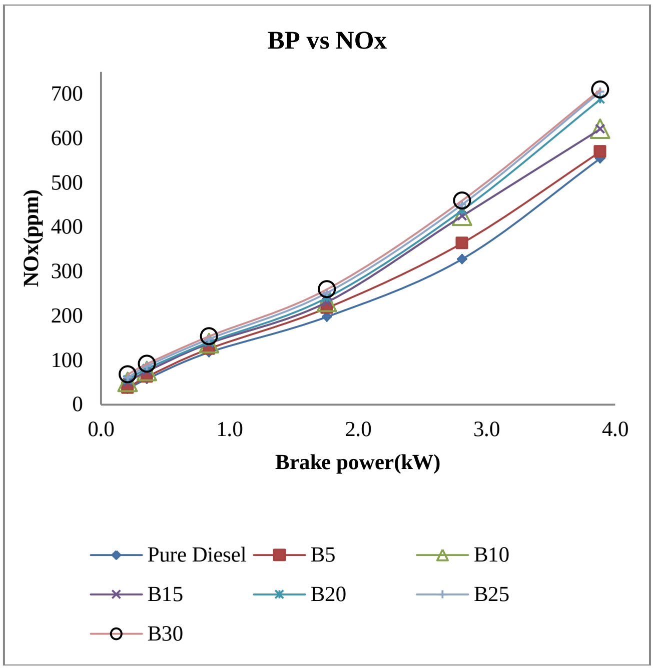

Figure 4: NO_x emissions versus brake power for various biodiesel blend percentages

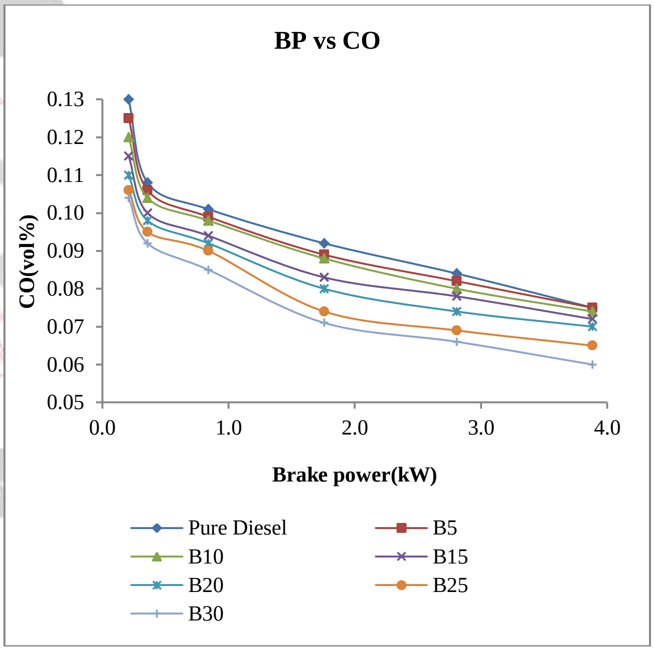

Figure 5: CO Emissions versus Brake Power For Various Biodiesel Blend Percentages

IV. CONCLUSION

The present paper deals with study of Palm oil based biodiesel and its varying blends with petro-diesel on Single Cylinder Four Stroke VCR Engine. The study shows the effect of fuel combustion as a function of its emission characteristics, engine efficiency and fuel capacity. The results show that blending of biodiesel gives optimum performance only upto 30% beyond that the results are not satisfactory.

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