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TO INVESTIGATION AND COMPARISON OF PERFORMANCE CHARACTERISTICS OF SINGLE CYLINDER, 4 Φ (VCR) DIESEL ENGINE USING SOYBEAN REFINED OIL AS BLEND WITH PURE DIESEL

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ABSTRACT

Petroleum Based fuel is a finite resource is rapidly depleting. Consequently, petroleum resources are not sufficient enough to last many years. Bio diesel and bio fuels are the alternative fuels made from vegetable oils, also used directly vegetable oils blended with petroleum diesel. These are friendlier for environment and have no effect on health and can reduce the emission compared with diesel fuel. These investigations will examine the use of refined soybean oil blended with Pure Diesel in single cylinder, four stroke VCR diesel engine. For these mixtures the brake thermal efficiency (BTE), Specific Fuel Consumption (SFC) and operating Performance Characteristics are calculated at various loading conditions at constant speed.

Keywords: Alternative Fuels, Blend, Refined Soybean Oil, Engine Performance, VCR Diesel Engine, Brake Thermal Efficiency and Specific Fuel Consumption.

INTRODUCTION

Diesel engines have been use since the last 18th century. Use of diesel in a CI engine is a well proven technology. The first diesel engine was developed by Dr. Rudolf Diesel and the use of plant oil as fuel for CI engine. Dr. Rudolf Diesel demonstrated his engine in Paris in 1900 using peanut oil as fuel. The plant oil fuels were not accepted much at that time. It was found that all the properties of plant oils were closed to diesel except viscosity and volatility. Once the technology becomes widely known in the 1900's the abundance and low cost of fossil fuels caused a paradigm shift away from vegetable based fuels. At the turn of current century, the same paradigm was beginning to shift back, due to rising fuel cost, the environmental impact and an abundance of waste feedback engines.

In this paper, to study the performance characteristics, the experimental setup consists of a single cylinder four stroke VCR (Variable Compression Ratio) diesel engines coupled with electrical eddy current dynamo meter.

EXPERIMENTAL SETUP

Computerized single cylinder, 4 strokes, direct injection, water cooled VCR (Variable Compression Ratio) diesel engine Test Rig. An engine indicator is fitted in control panel which sense pressure and crank angle data interface with computer. The engine and dynamo meter were interfaced to a control panel.

Performance Analysis Software "IC Engine Soft Ver. 8.5, Supplied by test rig supplier" Apex Innovation Pvt Ltd " was used for recording the test parameter such as fuel flow rate, air flow rate, temperature, loads etc. and for evaluating the performance characteristic such as Brake Thermal Efficiency, Specific Fuel Consumption, Indicated Thermal Efficiency, Mechanical efficiency (η_{mech}), Volumetric Efficiency (η_{vol}) etc.

The calorific value and density of the particular fuel was fed to the software for calculating the above said parameters. Soybean refined oil is blended with petroleum diesel in proportion like 15%, and 30%. These blends are termed as DSBB15, DSBB30. Engine performance using these blends and pure diesel have been performed and evaluated in IC engine lab at Moradabad Institute of Technology, Ram Ganga Vihar, Phase II, Moradabad, Uttar Pradesh (India).

1. Dynamo meter
2. Engine
3. Thermo couple
4. Exhaust gas analyzer
5. Fuel Tank
6. Fuel Measuring Devise
7. Computer Display

Specifications of Test Rig: (Tab 1.1)

Make and Model	Kirloskar-Oil Engine Limited
Engine Type	4 stroke, water cooled (TU I)
Number of Cylinder	Single
Bore	87.5 mm
Stroke	110 mm
Cubic Capacity	661 Cc (0.661liter)
Net Power	3.50 kw @ 1500 rpm
Compression ratio	12 to 18 :1
Max Speed	1500 rpm
Valves per Cylinder	Two
Number of nozzles	One (1)
Fuel injection type	Direct Injection
Max power	5.2 kw
Connecting rod length	234 mm
Orifice Diameter	20mm
Dynamometer arm length	185 mm
Rota meter	2 (engine and calorimeter)

Propriety of fuel used for Testing: (Tab 1.2)

Property	Units	Diesel	Soybean
Chemical Formula	-	C12H26	-
Calorific Value	KJ/kg	43350	39623
Self Ignition temperature	ºC	725	406
Final Boiling Temperature	ºC	369	300
Ignition delay period	Sec	0.002	-
Flame Propagation Rate	Cm/sec	10.5	-
Flame temperature	ºC	1715	-
Sp. Gravity at 15°C	-	0.893	0.916 and 0.922
Colour	-	Red/Orange	yellow
Sulphur content by weight	%	0.16	-
Kinematic viscosity at 39°C	Mm^2/sec	2.7	2.83
Density at 15°C	Kg/m^3	815	914
Viscosity at 25°C	Mm^2/s	5	50
Smoke Point	ºF or ºC	-	460 or 238
Pour point	ºC	-12	-14
Flash Point	°C	82	253
Cloud point	°C	2	-2
Fire Point	°C	59	290
Total Fat in 100g	%	Nil	16
Solubility in Water	-	Insoluble	Insoluble
Cetane No.	-	47.0	38.0

DYNAMO METER SPECIFICATION

1. Type - Eddy current
2. Max power - 7.5kw@1500-3000 rpm

EXPERIMENTAL PROCEDURE

1. First Switch on power supply.
2. Check water supply connections to engine and dynamo meter through rota meter.
3. On fuel supply, if separate arrangement is done for storage & supply of biodiesel.
4. The engine is started and warm up for 20 minutes.
5. Start the computer and select the mode (configure) to enter the data.
6. Select the run option.
7. Each test is conducted and data is stored at five different loads, as on No load, 25%, 50%, 75% and full load.
8. Engine is run for 10-25 minute for one test and data available is stored by log key at the end of time interval.
9. Next tests are conducted in sequence like pure diesel, DSBB15, and DSBB30.

ENGINE PERFORMANCE ANALYSIS

Measurement and results got by conducting trials using diesel and blends of refined soybean oil with the help of engine software are represented in the following table 1 to 6. These results are used to study various operating characteristics of engine such as SFC, BTE, Torque and Power etc.

Table for Observation & result of trial using pure diesel

Observation Table: On Pure Diesel (Tab.1)

No.	Speed (Kg)	Load (kg)	T1 (ºC)	T2 (ºC)	T3 (ºC)	T4 (ºC)	T5 (ºC)	T6 (ºC)	Fuel cc/min	Air (mm)	F1	F2	F3	F4
1	1483	0.36	26.53	37.99	26.54	34.26	177.20	132.28	6.00	51.03	0.30	23.50	150	75
2	1481	3.26	26.41	41.68	26.40	38.12	224.62	157.12	8.00	52.60	0.40	23.86	150	75
3	1458	6.26	26.39	43.09	26.39	41.58	266.98	176.92	10.00	52.72	0.50	23.89	150	75
4	1449	9.14	26.39	45.40	26.40	44.15	311.93	196.72	13.00	53.27	0.65	24.01	150	75
5	1427	12.13	26.40	48.24	26.41	47.41	373.30	219.26	15.00	53.04	0.75	23.96	150	75

Result Table: On Pure Diesel (Tab.2)

No.	Torque (Nm)	B.P. (Kw)	F.P. (Kw)	I.P. (Kw)	BMEP (bar)	IMEP (bar)	Bth η(%)	Ith η (%)	Mech η(%)	SFC Kg/kwh	VolE (%)	A/F ratio
1	0.65	0.10	1.64	1.74	0.12	0.10	2.70	46.62	5.79	2.96	66.66	78.55
2	5.92	0.92	1.47	2.39	1.12	0.92	18.41	47.92	38.42	0.43	67.77	59.81
3	11.36	1.73	1.31	3.05	2.16	1.73	27.83	48.92	56.89	0.29	68.92	47.91
4	16.59	2.52	1.20	3.72	3.15	2.52	31.07	45.93	67.64	0.26	69.71	37.04
5	22.01	3.29	1.02	4.30	4.18	3.29	35.19	46.05	76.41	0.23	70.63	32.03

Table for Observation and result of using DSBB15

Observation Table: On DSBB15 (Tab.3)

No.	Speed (kg)	Load (kg)	T1 (ºC)	T2 (ºC)	T3 (ºC)	T4 (ºC)	T5 (ºC)	T6 (ºC)	Fuel cc/mn	Air (mm)	F1	F2	F3	F4
1	1474	0.26	28.58	37.12	28.58	36.62	150.36	113.00	5.00	51.67	0.25	23.65	150	75
2	1458	3.26	28.31	38.53	28.31	36.39	186.58	134.49	7.00	51.81	0.35	23.68	150	75
3	1449	6.35	28.16	41.34	28.16	37.63	248.72	165.90	11.00	52.96	0.55	23.94	150	75
4	1429	9.15	27.73	43.50	27.74	39.66	305.40	189.34	13.00	52.00	0.65	23.72	150	75
5	1410	12.13	27.62	46.95	27.63	43.65	387.72	221.26	16.00	52.90	0.80	23.93	150	75

Result Table: On DSBB15 (Tab.4)

No.	Torque (Nm)	B.P. (Kw)	F.P. (Kw)	I.P. (Kw)	BMEP (bar)	IMEP (bar)	Bth η(%)	Ith η(%)	Mech η(%)	SFC Kg/kwh	VolE (%)	A/F ratio
1	0.46	0.07	1.73	1.80	0.09	2.22	2.30	57.76	3.98	3.48	67.50	94.86
2	5.92	0.90	1.65	2.55	1.12	3.18	20.70	58.56	35.36	0.39	68.32	67.84
3	11.53	1.75	1.46	3.21	2.19	4.02	25.52	46.81	54.53	0.31	69.51	43.65
4	16.60	2.48	1.25	3.73	3.15	4.74	30.66	46.07	66.56	0.26	69.84	36.60
5	22.02	3.25	1.31	4.56	4.18	5.87	32.61	45.77	71.23	0.25	71.39	29.99

Table for Observation & result of using DSBB30

Observation Table: On DSBB30 (Tab.5)

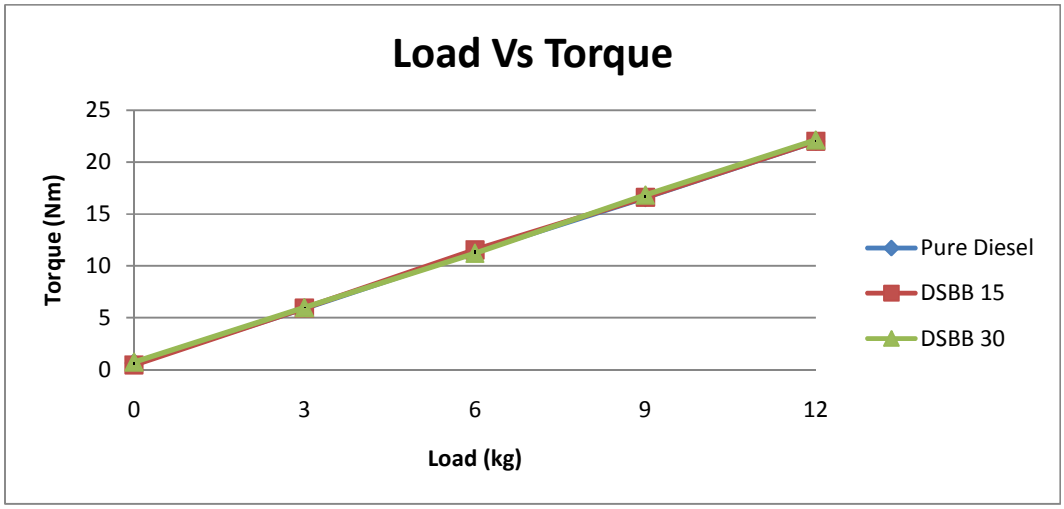
No.	Speed (kg)	Load (kg)	T1 (ºC)	T2 (ºC)	T3 (ºC)	T4 (ºC)	T5 (ºC)	T6 (ºC)	Fuel cc/min	Air (mm)	F1	F2	F3	F4
1	1478	0.40	27.35	36.13	27.36	39.48	168.75	130.42	5.00	52.33	0.25	23.80	150	75
2	1456	3.30	27.30	38.14	27.30	38.79	197.25	144.44	8.00	52.68	0.40	23.88	150	75
3	1454	6.18	27.26	40.62	27.25	40.23	260.60	174.16	10.00	53.01	0.50	23.95	150	75
4	1426	9.27	27.95	43.76	27.94	44.01	320.86	199.12	13.00	51.82	0.65	23.68	150	75
5	1409	12.19	27.70	47.65	27.70	50.04	402.85	230.97	16.00	50.78	0.80	23.44	150	75

Result Table: On DSBB30 (Tab.6)

No.	Torque (Nm)	B.P. (Kw)	F.P. (Kw)	I.P (Kw)	BMEP (bar)	IMEP (bar)	Bth η(%)	Ith η(%)	Mech η(%)	SFC Kg/kwh	VolE (%)	A/F ratio
1	0.73	0.11	1.67	1.78	0.14	2.19	3.64	57.13	6.37	2.20	67.74	95.46
2	5.98	0.91	1.53	2.45	1.14	3.05	18.29	49.06	37.28	0.44	68.99	59.86
3	11.22	1.71	1.42	3.13	2.13	3.90	27.42	50.22	54.60	0.29	69.30	48.04
4	16.82	2.51	1.37	3.88	3.19	4.94	30.99	47.91	64.68	0.26	69.86	36.53
5	22.12	3.26	1.30	4.57	4.20	5.88	32.73	45.80	71.45	0.24	69.99	29.38

PERFORMANCE CHARACTERISTIC GRAPHS

1) Load Vs Torque for various blends of refined soybean oil and Diesel



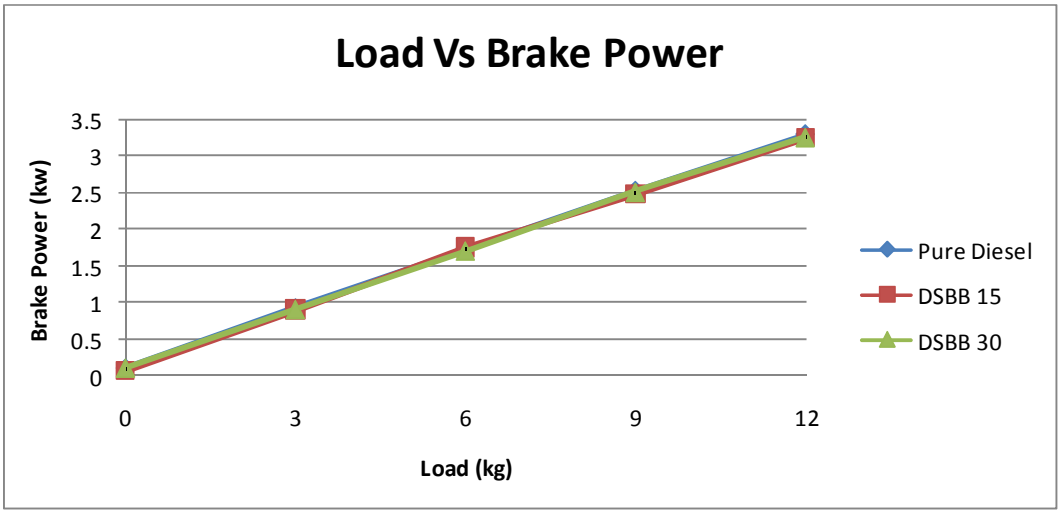
Graph 1.1

The graph shows the effect of refined soybean oil blends and diesel fuel on engine torque. The values of torque for different blends and diesel fuel are given in test results tables. The engine torque is approximately same with increasing loads for bio fuel and diesel. It is observed that the

torque values of soybean oil blends are slightly lower than diesel at all load conditions. But there is no significant variation.

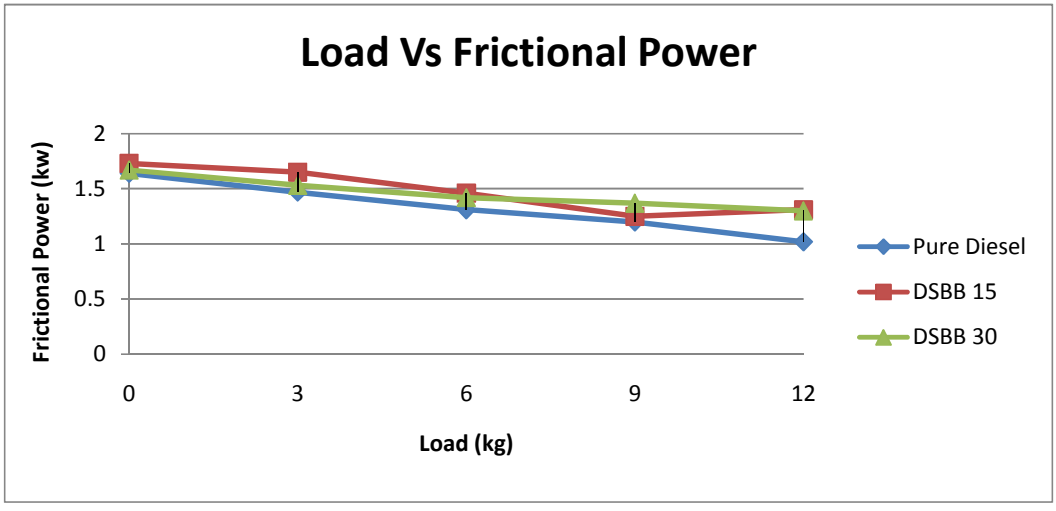
2) Load Vs Brake Power (BP) for various blends of refined soybean oil and diesel

This graph shows the variation of BP for refined soybean oil blends and diesel at different loads. The values of BP for each fuel are given in test result tables. It is observed that the BP for refined soybean oil blends is slightly more than diesel at 25% load condition.DSBB15 has BP is slightly more than diesel at 50% and DSBB30 has BP is slightly below than diesel at 75% and full load condition.



Graph 1.2

3) Load Vs Frictional Power for various blends of refined soybean oil & diesel



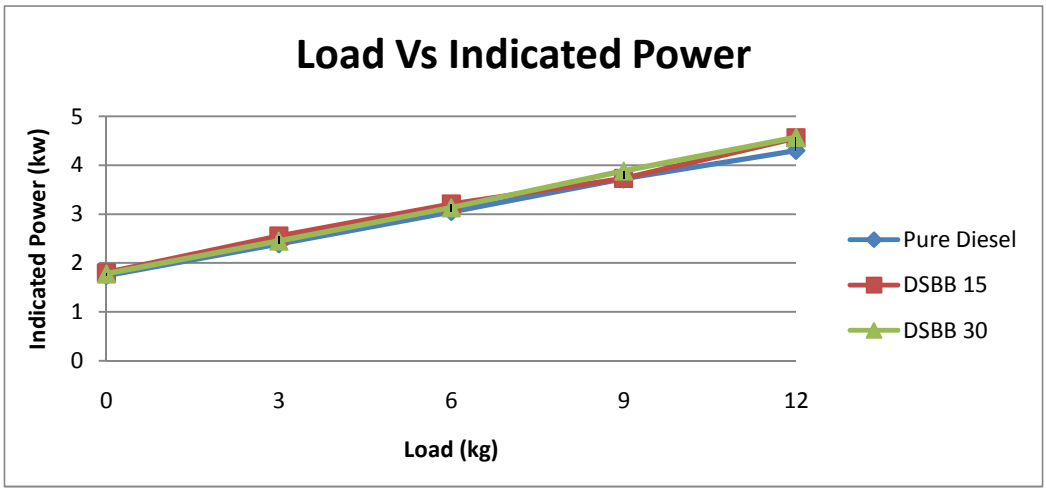
Graph 1.3

The variation of friction power (FP) at different loads for refined soybean oil blends and diesel are shown in graph 1.3. The values of FP for these fuels are given in test tables. DSBB15 has

less FP than diesel at 75% load only. DSBB15, DSBB30 have approx same FP but more than diesel at full load condition.

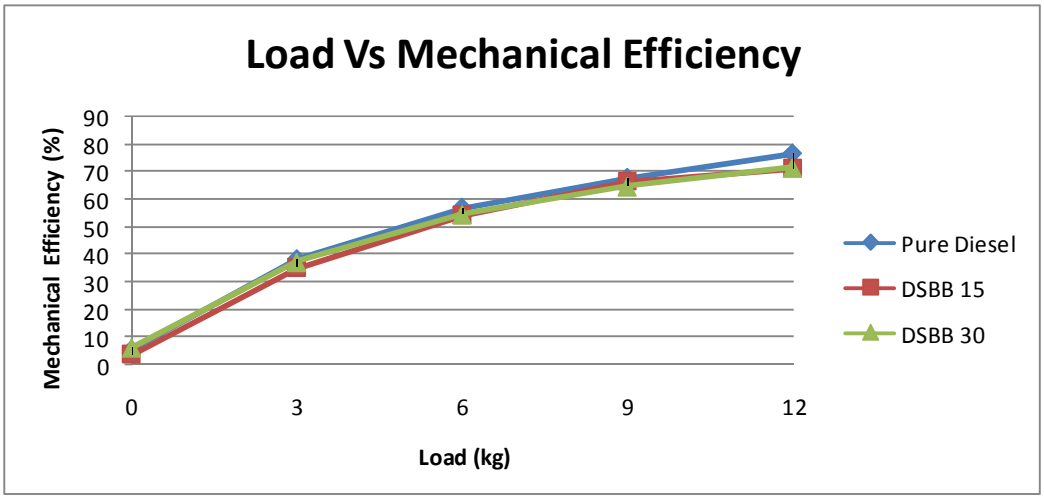
4) Load Vs Indicated Power (IP) for various blends of refined soybean oil and diesel

The variation of IP with load for refined soybean oil based blends and diesel are shown in graph 1.4. The values of IP for each fuel are given in result tables. DSBB15 has IP more than DSBB30 and Diesel at 25% and 50% load conditions. But at 75% and full load condition IP more than diesel.



Graph 1.4

5) Load Vs Mech. Efficiency for various blends of refined soybean oil & Diesel

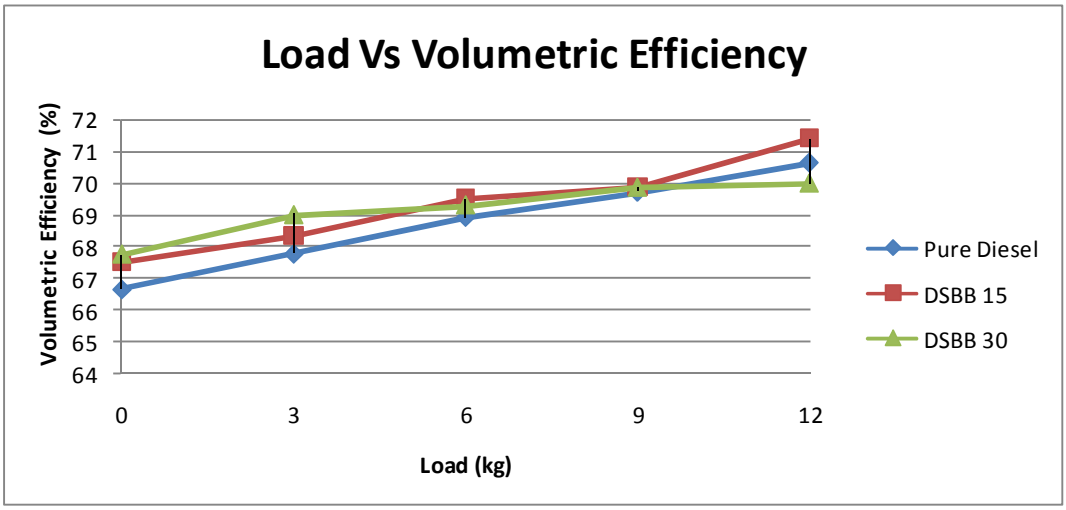


Graph 1.5

The variation of mechanical efficiency with load for refined soybean oil based blends and diesel is shown in graph 1.5. The values of mechanical efficiency for each fuel are given in results tables. DSBB30 has slightly lower than diesel and more than DSSB15 at 25% load conditions. For DSSB15 and DSSB30 has same but less than diesel at 50% and full load condition.

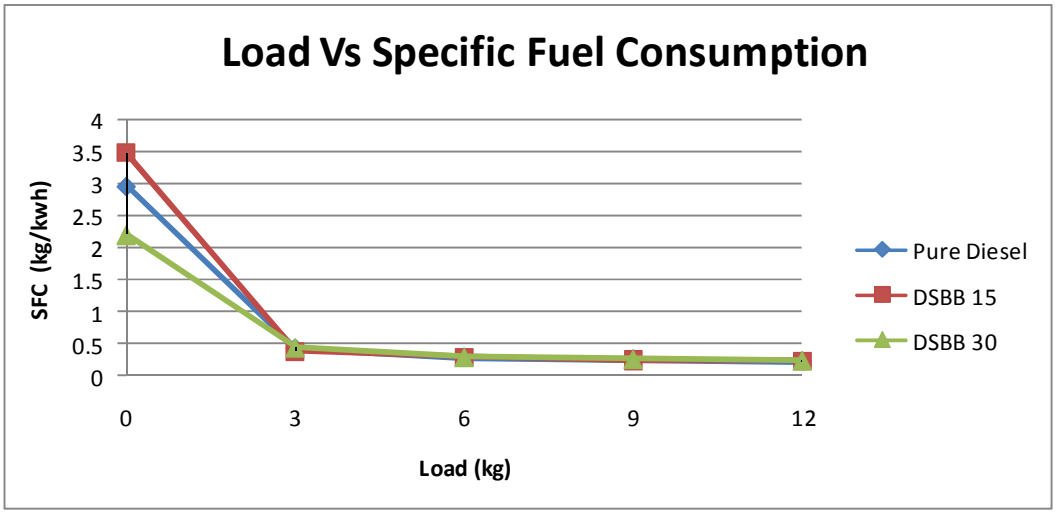
6) Load Vs Vol. efficiency for various blends of refined soybean oil and diesel

The variation of vol. efficiency with load for refined soybean oil based blends and diesel is shown in graph 1.6. The values of vol. efficiency for each fuel are given in results tables. DSBB30 has vol. efficiency more than DSSB and Diesel at 25% and 50% load conditions. At load 75% has same volumetric efficiency. DSBB15 has vol. efficiency more than diesel and DSSB30 has less than diesel at full load condition.



Graph 1.6

7) Load Vs specific fuel consumption (SFC) for various blends of refined soybean oil and diesel

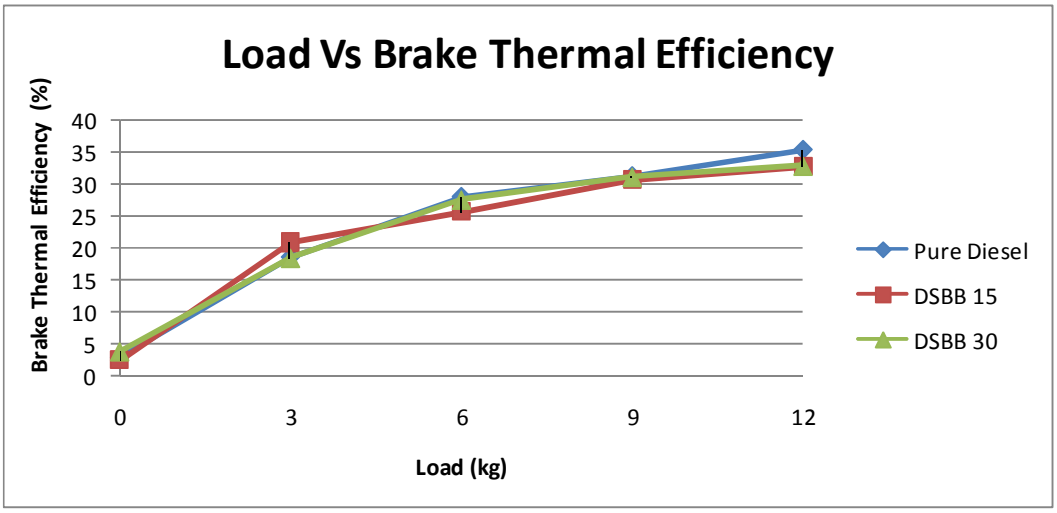


Graph 1.7

The variation of SFC with load for refined soybean oil based blends and diesel is shown in graph 1.7. The values of SFC for each fuel are given in results tables. DSSB15, DSSB30 has SFC less only at zero loads and nearly equal to diesel at full load only.

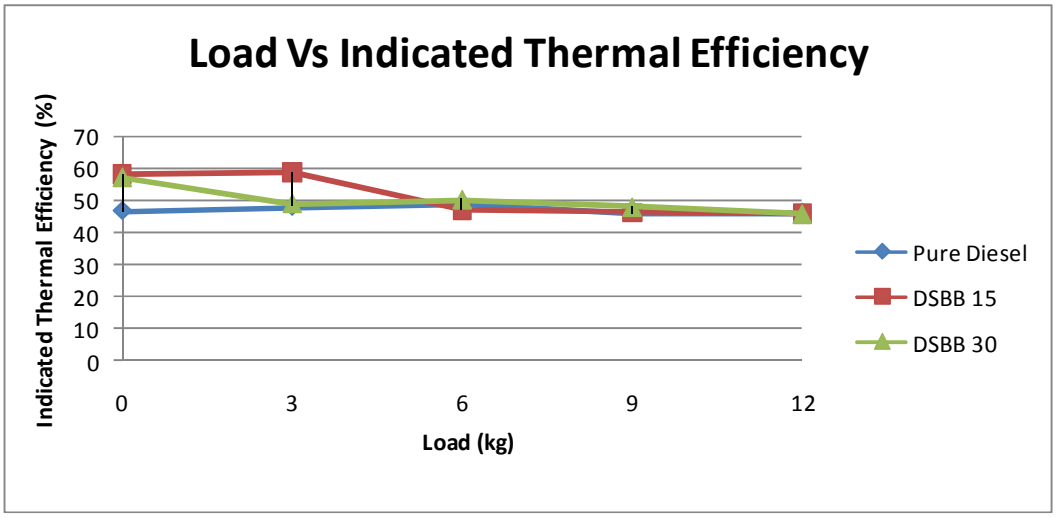
8) Load Vs Brake Thermal Efficiency (BTE) for various blends of refined soybean oil and diesel

The variation of BTE with load for refined soybean oil based blends and diesel is shown in graph. The values of BTE for each fuel are given in results tables. DSSB15 has BTE more than DSSB30 and Diesel at 25% load and slightly less than diesel at 50%. All fuel has same BTE at 75% load condition. At full load DSBB15 and DSBB30 has BTE less than diesel fuel.



Graph 1.8

9) Load Vs Indicated Thermal Efficiency (ITE) for various blends of refined soybean oil and diesel



Graph 1.9

The variation of ITE with load for refined soybean oil based blends and diesel is shown in graph 1.9. The values of ITE for each fuel are given in results tables. DSBB15 has ITE more than DSBB30 and Diesel at 25% load condition. DSBB30 has ITE slightly more than diesel and DSBB15 at 50% and 75% loads and same at full load condition.

CONCLUSIONS

The Soybean refined oil with 15%, and 30% blend with petroleum diesel are used in the computerized VCR diesel engine without any modification in engine or fuel system, performance evaluation**.** It was observed that the Performance operating characteristics that is Torque, Brake power, frictional power, indicated power, brake thermal efficiency, Indicated thermal efficiency, specific fuel consumption, volumetric efficiency, and mechanical efficiency is nearly equal to petroleum diesel at various loading conditions at constant speed for Soybean refined oil blend with diesel at 15% (DSBB15) and 30% (DSBB30) oil blends. Therefore, soybean is a cheap raw material and its low operating cost in refining production make this study a capable one for possible technological applications. Soybean refined oil blended with diesel fuel can be used as an alternative fuel in conventional diesel engines without any major modification. The life of the engine and the pollutants coming out from the engine can be studied further to make this fuel best alternative of engines.

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