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INVESTIGATION AND COMPARISON OF PERFORMANCE CHARACTERISTICS OF SINGLE CYLINDER, 4 STROKE (VCR) DIESEL ENGINE USING BLEND OF SUNFLOWER REFINED OIL WITH PURE DIESEL

Abhishek Gaikwad[1], Avnish kumar[2], Abhay Singh[3], Amit Kumar[4]

Assistant Professor[1], Scholars[2, 3, 4]
(Department of Mechanical Engineering, SSET, SHIATS,
Naini Allahabad Uttar Pradesh, India)

ABSTRACT

A comparative experimental study was conducted to evaluate the performance of single cylinder four stroke VCR (variable compression ratio) diesel engine when fueled with sunflower blends with diesel fuel (15/85 or 30/70 volumetrically). Tests were also carried out with diesel fuel to be used as a reference point. Engine Power, Torque, BSFC, Thermal efficiency, brake thermal efficiency (BTE) and Specific Fuel Consumption (SFC) were recorded for tested fuel. These Investigations will help the nature in finding out the substitute of Diesel and also maximize the use of refined sunflower oil blends with Pure Diesel in single cylinder, four stroke VCR diesel engine. For these mixtures the operating Performance Characteristics of single cylinder,4 stroke VCR diesel engine using blend of refined sunflower oil at various loading conditions at constant speed are recorded and calculated to compare it with pure diesel fuel.

KEY WORDS: Alternative Fuels, Blend, Refined Sunflower Oil, Engine Performance, VCR Diesel Engine.

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. We have made an effort in this paper to study the performance characteristics of blends of sunflower oil with diesel at various ratios. The experimental setup consists of a single cylinder four stroke VCR 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 is used. 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. Sunflower refined oil is blended with petroleum diesel in proportion like 15%, and 30%. These blends are termed as DSFB15, DSFB30. Engine performance using these blends and pure diesel have been recorded and calculated 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**	**Sunflower**
Chemical Formula	-	C12H26	-
Calorific Value	KJ/kg	43350	39525
Self Ignition temperature	ºC	725	358
Final Boiling Temperature	ºC	369	682
Ignition delay period	Sec	0.002	-
Flame Propagation Rate	Cm/sec	10.5	-
Flame temperature	ºC	1715	-
Colour	-	Red/Orange	Yellow
Kinematic viscosity at 39˚C	Mm^2/sec	2.7	3.43
Density at 15˚C	Kg/m^3	815	918.8
Viscosity at 25˚C	Mm^2/s	5	50
Smoke Point	ºF or ºC	-	437 or 225
Pour point	ºC	-12	-14
Flash Point	˚C	82	253
Cloud point	˚C	2	-
Fire Point	˚C	59	-
Total Fat in 100g	%	Nil	11
Solubility in Water	-	Insoluble	Insoluble
Cetane No.	-	47.0	49.0

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, DSFB15, and DSFB30.

ENGINE PERFORMANCE ANALYSIS

Measurement and results got by conducting trials using diesel and blends of refined sunflower 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, 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 DSFB15

Observation Table: On DSFB15 (Tab 2.3)

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	1502	0.26	28.13	39.89	28.13	38.97	168.15	124.94	6.00	51.50	0.30	23.61	150	75
2	1488	3.15	28.04	41.66	28.04	38.66	211.55	147.72	9.00	54.18	0.45	24.22	150	75
3	1457	6.24	27.93	41.25	27.91	38.96	243.85	162.83	10.00	54.60	0.50	24.31	150	75
4	1449	9.04	27.83	44.48	27.83	40.64	294.28	185.11	13.00	53.21	0.65	24.00	150	75
5	1426	12.14	27.66	48.28	27.67	44.64	365.91	213.97	15.0	53.49	0.75	24.06	150	75

Result Table: On DSFB 15(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	0.47	0.07	1.60	1.67	0.09	2.02	1.97	44.70	4.41	4.05	66.13	78.91
2	5.72	0.89	1.47	2.36	1.09	2.88	15.88	42.12	37.71	0.50	68.46	53.96
3	11.32	1.73	1.16	2.88	2.15	3.59	27.72	46.27	59.91	0.29	70.19	48.75
4	16.40	2.49	1.11	3.59	3.12	4.50	30.72	44.37	69.23	0.26	69.67	37.02
5	22.02	3.29	0.97	4.26	4.18	5.42	35.18	45.56	77.21	0.23	70.98	32.17

Table for Observation & result of using DSFB 30

Observation Table: On DSFB 30 (Tab.5)

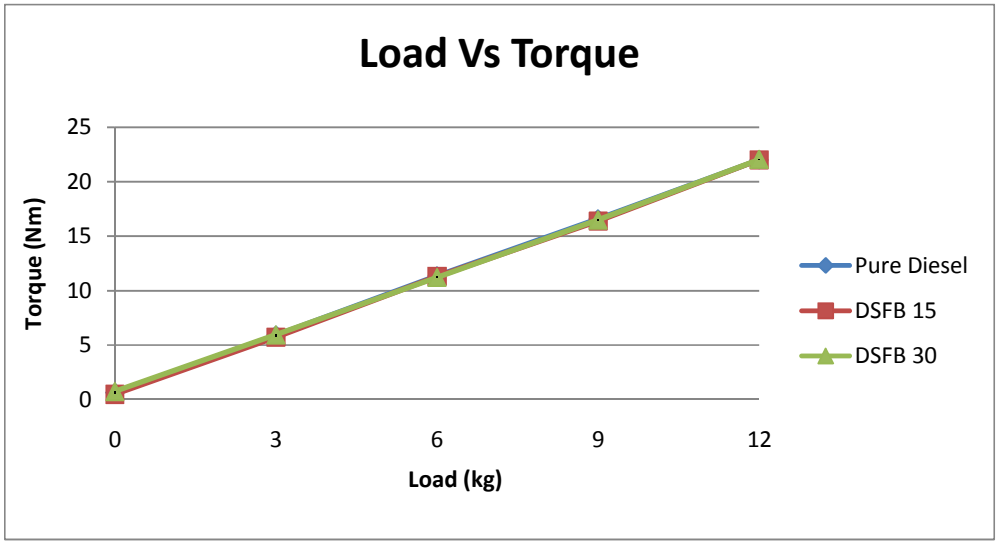
No.	Speed (kg)	Load (kg)	T1 (ºC)	T2 (ºC)	T3 (ºC)	T4 (ºC)	T5 (ºC)	T6 (ºC)	Fuel cc/min	Air (mm)	F1	F2	F3	F4
1	1489	0.41	27.25	37.17	27.25	38.16	184.59	141.43	6.00	52.35	0.30	23.80	150	75
2	1473	3.28	27.14	39.68	27.16	38.11	214.59	153.96	8.00	53.43	0.40	24.05	150	75
3	1457	6.18	27.13	41.81	27.13	39.25	249.10	168.70	10.00	53.80	0.50	24.13	150	75
4	1449	9.08	27.09	44.77	27.10	41.07	298.04	188.25	13.00	53.75	0.65	24.12	150	75
5	1428	12.15	27.03	47.37	27.03	43.84	363.53	211.90	17.00	52.98	0.85	23.94	150	75

Result Table: On DSFB 30 (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	0.74	0.12	1.57	1.69	0.14	2.06	3.09	45.20	6.84	2.59	67.25	79.56
2	5.95	0.92	1.34	2.26	1.13	2.78	18.40	45.33	40.58	0.43	68.68	60.29
3	11.21	1.71	1.24	2.95	2.13	3.68	27.44	47.40	57.88	0.29	69.67	48.39
4	16.49	2.50	1.06	3.56	3.13	4.46	30.88	43.95	70.25	0.26	70.02	37.21
5	22.05	3.30	1.06	4.36	4.19	5.54	31.11	41.16	75.59	0.26	70.54	28.25

PERFORMANCE CHARACTERISTIC GRAPHS

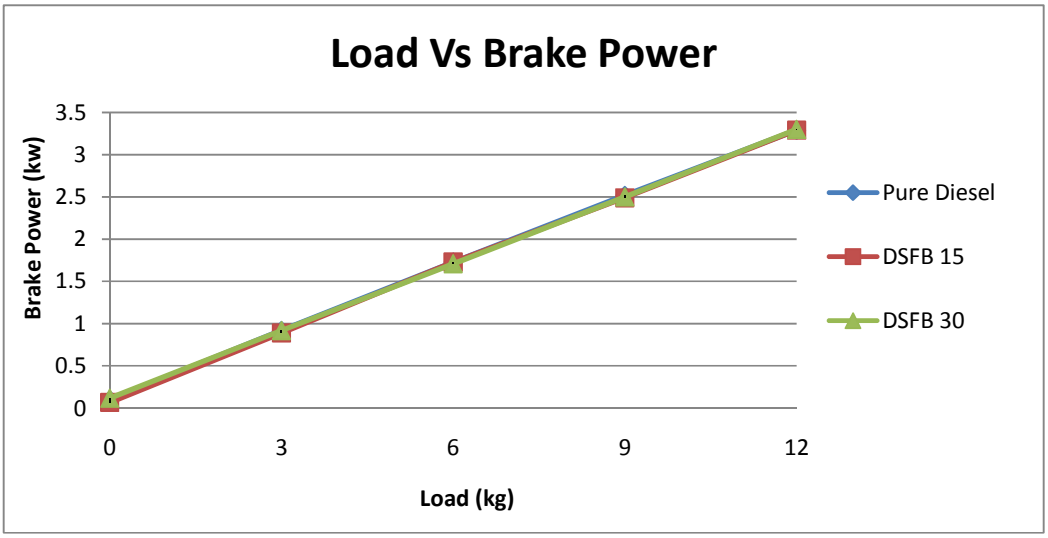
1) Load Vs Torque for various blends of refined sunflower oil and Diesel



Graph 1.1

The effect of refined sunflower oil and its blends and diesel fuel on engine torque are as shown in above graph. The values of torque for fuel are given in test results tables. The engine torque approximately same with increasing loads for bio fuel and diesel. It is observed that the torque values of sunflower oil blends are slightly same to the diesel at all load conditions.

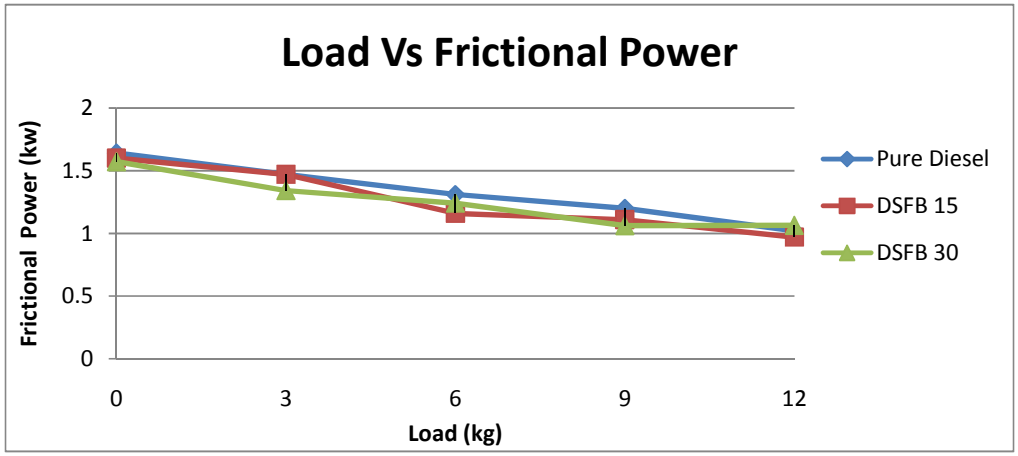
2) Load Vs B.P. for various blends of refined sunflower oil and diesel



Graph 1.2

The Variation of brake power with load for refined sunflower oil blends and diesel is shown in graph 1.2. The values of Brake power for each fuel are given in test result tables. It is observed that the brake power for refined sunflower oil blendsDSFB30 has BP slightly more than diesel at 25%load.DSFB15, DSFB30 has Brake Power is slightly less than diesel at 75% load and all fuel have BP same at full load condition.

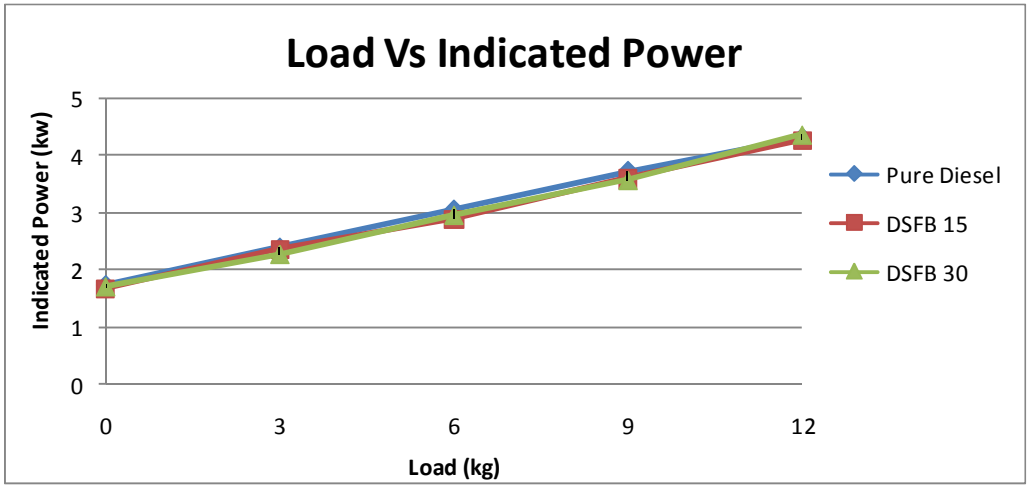
3) Load Vs F.P. for various blends of refined sunflower oil and diesel



Graph 1.3

The Variation of frictional power with load for refined sunflower oil blends and diesel are shown in graph 1.3. The values of frictional power for each fuel are given in test tables. DSFB30 has less frictional power than diesel and DSFB15 at 25% load. DSFB15, DSFB30 have approx same frictional power but less than diesel at 50%and 75% load but DSFB15 has slightly less than remaining flues at full load condition.

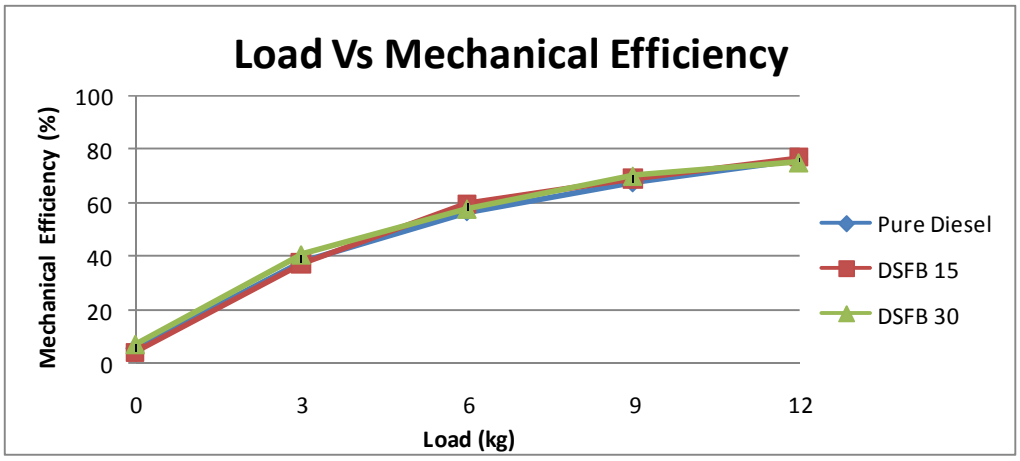
4) Load Vs I.P. for various blends of refined sunflower oil and diesel



Graph 1.4

The variation of indicated power with load for refined sunflower oil based blends and diesel are shown in graph above. The values of indicated power for each fuel are given in result tables. DSFB15 and DSFB30 have IP less than the Diesel at 25%, 50% and 75% load conditions.

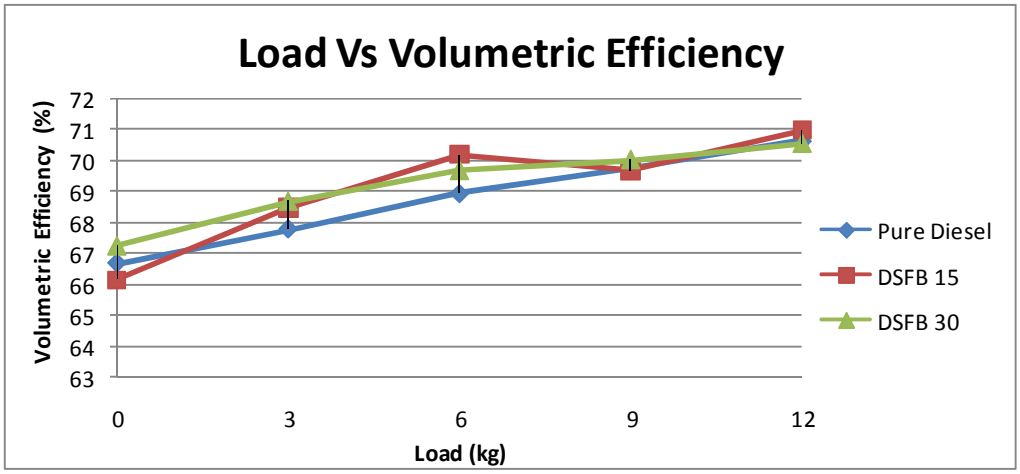
5) Load Vs Mech.Eff. for various blends of refined sunflower oil and diesel



Graph 1.5

The variation of mechanical efficiency with load for refined sunflower oil based blends and diesel is shown in graph. The values of mechanical efficiency for each fuel are given in results tables. DSFB15 has ME slightly less than diesel and DSFB30 at 25% load.DSFB30 has ME slightly less than DSFB15 and more than diesel at 50% and DSFB15 slightly more than diesel and DSFB30 at full load condition.

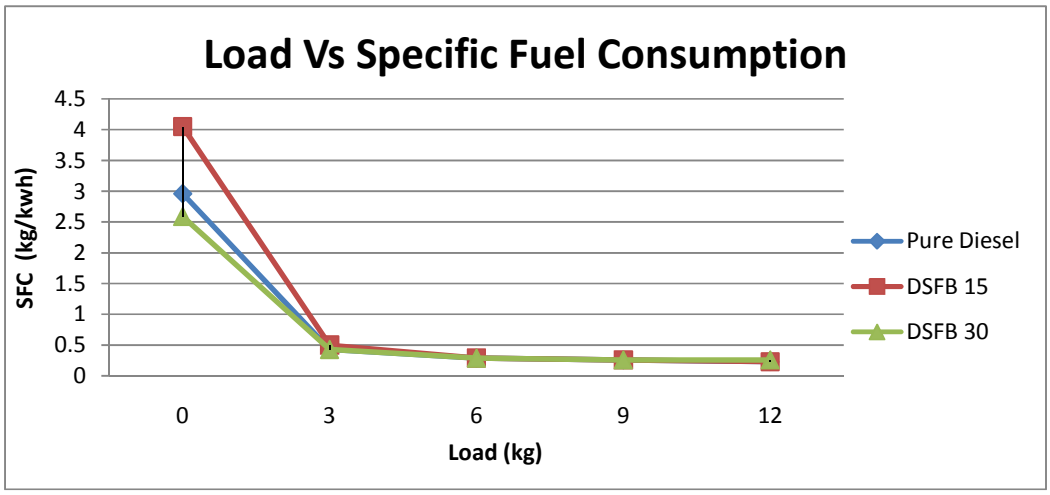
6) Load Vs Vol.eff. for various blends of refined sunflower oil and diesel



Graph 1.6

The variation of volumetric efficiency with load for refined sunflower oil based blends and diesel is shown in graph. The values of volumetric efficiency for each fuel are given in results tables. DSFB30 and DSFB15has volumetric efficiency more than Diesel at 25% and at 50% load DSFB15; DSFB30 has VE more than diesel. At load 75% DSFB30 slightly more than DSFB15 and diesel and DSFB15 has more than remaining both at full load condition.

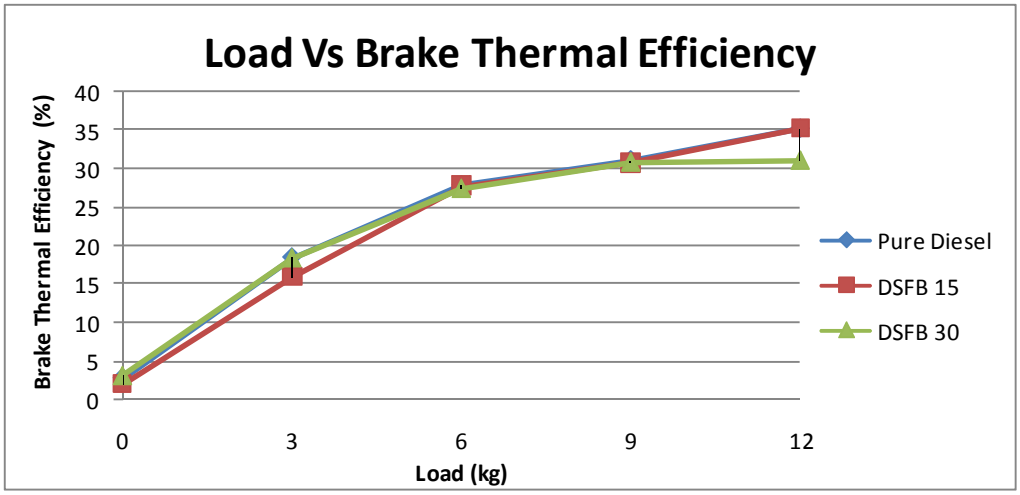
7) Load Vs S.F.C. for various blends of refined sunflower oil and diesel



Graph 1.7

The variation of SFC with load for refined sunflower oil based blends and diesel is shown in graph. The values of SFC for each fuel are given in results tables. DSFB15, DSFB30 has SFC less only at all loads and nearly equal to diesel at full load only.

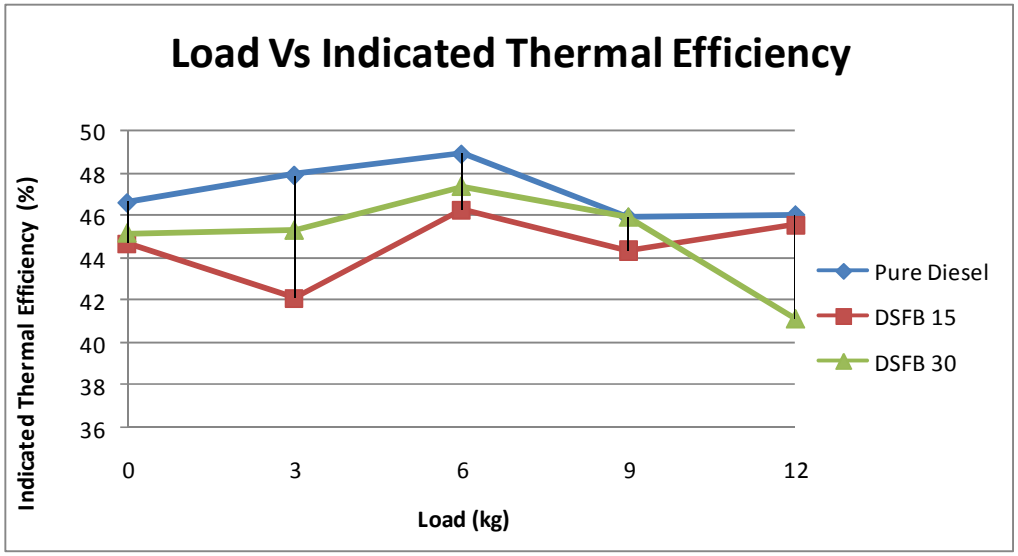
8) Load Vs B.T.E for various blends of refined sunflower oil and diesel



Graph 1.8

The variation of Brake Thermal efficiency with load for refined sunflower oil based blends and diesel is shown in graph. The values of Brake Thermal efficiency for each fuel are given in results tables. DSFB30 slightly equal to Diesel but more than to DSFB15 at 25% load. All fuel has same BTE at 50% and 75% load. At full load condition DSFB15 and diesel has same but more than DSFB30.

9) Load Vs I.T.E. for various blends of refined sunflower oil and diesel



Graph 1.9

The variation of Brake Thermal efficiency with load for refined sunflower oil based blends and diesel is shown in graph. The values of Brake Thermal efficiency for each fuel are given in results tables.DSFB30 has ITE more than DSFB15 but less than Diesel at 25% and 50% load condition. DSFB15 has ITE less than diesel and DSFB30 at 75% load conditions and DSFB30 has ITE less than diesel at full load condition.

CONCLUSIONS

The sunflower 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 are Torque, Brake power, friction 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 sunflower refined oil blend with diesel at 15% (DSFB15) and 30% (DSFB30) oil blends. Therefore, sunflower is a cheap raw material and its low operating cost in refining production make this study a capable one for possible technological applications. Sunflower refined oil blended with diesel fuel can be used as an alternative fuel in diesel engines without any major modification.

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