Study of the use of Blends of Orange Peel Oil and Cotton Seed Oil as Alternate Fuel for CI Engines

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***Abstract*— As a renewable, sustainable and alternative fuel for compression ignition engines, biodiesel instead of diesel has been increasingly leads to study its effects on engine performances and exhaust emissions in the recent 15 years. But these studies have been not properly reviewed to favor understanding and popularization for biodiesel so far. The use of biodiesel leads to the imperceptible power loss, the increase in fuel consumption and increase in break thermal efficiency in conventional diesel engines with no or few modifications. It also suits to reduce carbon deposits and wear of the key engine parts. Therefore, the blends of biodiesel with small content in place of petroleum diesel can help in controlling air pollution and easing the pressure on scarce resources without significantly sacrificing engine power and economy. The test with various blends of biodiesels is conducted on variable compression ratio CI engine. The results are analyzed. B20 blend is found suitable for improving performance & reducing engine emissions.**

***Keywords*—Biodiesel blends, Thermal Efficiency, Emissions, bsfc**

1. INTRODUCTION

CI engine plays major role in engineering & automobile industry in current scenario. Reduction in emissions and solving the energy crisis, designing CI engines with low emission and less energy consumption has always be an objective for researchers across the globe. However, with the development of new technologies, today's diesel engines have better emission characteristics and the less energy consumption compared with its predecessor. But, still lot of research on diesel engines aimed to achieve goal of clean and effective diesel engine. Accordingly, research on a clean burning fuel instead of conventional fuel is advisable, which could not only decrease exhaust gas to a great extent, but, also provide more options of energy sources. The use of alternative fuels for internal combustion engines has attracted a great deal of attention due to fossil fuel crisis and also GHG impact. Successful alternative fuel should comply environmental and energy security needs without reducing engine operating performance. Most biodiesel oils, particularly of the non-edible type can be used as fuel in diesel engines. One of the promising alternative fuels considered for diesel engine is biodiesel.

Biodiesel fuels are renewable, as the carbon released by the burning of biodiesel fuel is used when the oil crops undergo photosynthesis. Biodiesel also offers the advantage of being able to use in existing diesel engines without engine alterations. The alkyl monoester of fatty acids as bio-diesel which was obtained from renewable oil and fats materials by transesterification reaction is a good alternative. Biodiesel can be obtained from raw vegetable oil by transesterification with methanol or ethanol after chemical reactions. Vegetable oils present a very promising alternative to diesel oil since they are renewable and have similar properties as of diesel. Many researchers have studied the use of vegetable oils in diesel engines. This recommends the intensive studies on the use of alternative fuels especially renewable ones like vegetable oils and alcohols. Biodiesels such as Jatropha, Karanja, Sunflower and cottonseed are some of the popular biodiesels currently considered as substitute for diesel.
In the present energy scenario lot of efforts is being focused on improving the thermal efficiency of IC engines with reduction in emissions. The problem of increasing demand for high brake power and the fast depletion of the fuels demand severe controls on power and a high level of fuel economy.

1.1 Biodiesel Standard

Biodiesel has a number of standards for its quality. The European standard for biodiesel is EN 14214, which is translated into the respective national standards for each country that forms the CEN (European Committee for Standardization) area e.g., for the United Kingdom, BS EN 14214 and for Germany DIN EN 14214. It may be used outside the CEN area as well. The main difference that exists between EN 14214 standards of different countries is the national annex detailing climate related requirements of biodiesel in different CEN member countries.

Table 1.1: ASTM D-6751 / BIS standards for Biodiesel

SN	**ASTM D-6751 / BIS standards for Biodiesel**	
11	Flash point (closed cup)	130°C min. (150°C average)
22	Water and sediment	0.050% by vol., max.
33	Kinematic viscosity at 40°C	1.9-6.0 mm2/s
44	Sulfated ash	0.020% by mass, max.
55	Sulfur	0.05% by mass, max.
66	Copper strip corrosion	No. 3 max
77	Cetane	47 min.
88	Carbon residue	0.050% by mass, max.
99	Acid number -- mg KOH/g	0.80 max.
110	Free glycerin	0.020 % mass
111	Total glycerine (free glycerine and unconverted glycerides combined)	0.240% by mass, max.
112	Phosphorus content	0.001 max. % mass
113	Distillation	90% @ 360°C

1.2 Comparisons of Properties of Biodiesel & Diesel:

Table 1.2: Properties of Biodiesel and Diesel comparisons

SS N	Test	Unit	Diesel	Blend		
			B00%	B20%	B30%	B40%
11	Color		Golden	NA	NA	NA
22	Density	Kg/m^3	830	835	846	858
33	Viscosity	Cst	2.9	3.6	4.1	4.6
44	Cetane Number	_	51	51.3	51.4	52.4
55	CV	MJ/kg	42.5	41.3	41.18	40.1
66	Flash Pt.	℃	65	76	108	130
77	Fire pt.	℃	72	84	117	141

2. EXPERIMENTAION

2.1 Experimental Setup

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed **tilting cylinder block** arrangement.

Table 2.1: Engine Specifications

Product: VCR Engine test setup 1 cylinder, 4 stroke, Diesel (Computerized) **Product code:** 234 **Engine:** Make Kirloskar, Type 1 cylinder, 4 stroke Diesel, water cooled, power 3.5 kW at 1500 rpm, stroke 110 mm, bore 87.5 mm. 661 cc, CR 17.5, Modified to VCR engine CR range 12 to 18 **Dynamometer:** Type eddy current, water cooled, with loading unit **Propeller shaft:** With universal joints **Air box:** M S fabricated with orifice meter and manometer **Fuel tank:** Capacity 15 lit with glass fuel metering column

Calorimeter: Type Pipe in pipe
Piezo sensor: Range 5000 PSI, with low noise cable
Crank angle sensor: Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device: NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit: Make-Cuadra, Model AX-409.
Digital milivoltmeter: Range 0-200mV, panel mounted
Temperature sensor: Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter: Type two wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type two wire, Input Thermocouple, Range 0–1200 Deg C, Output 4–20 mA
Load indicator: Digital, Range 0-50 Kg, Supply 230VAC
Load sensor: Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter:DP transmitter, Range 0-500 mm WC
Air flow transmitter: Pressure transmitter, Range (-) 250 mm WC

2.2 Design of Experiment

1. Selection of control parameters
The following control parameters are selected for the experimental investigation with the three levels.

Table 2.2: Control parameters and their levels

Factors	Level 1	Level 2	Level 3
Blend Ratio (%)	20	30	40
Load (kg)	5	8	10
Speed (rpm)	1550	1500	1450

2. Selection of Taguchi orthogonal array
Factors: 3 and Levels: 3
A L9 orthogonal array with three columns and nine rows is be considered for experiments & analysis.
No. of Runs: 9

Table 2.3: L9 Orthogonal Array

Experiment No.	Blend Ratio (%)	Load (kg)	Speed (rpm)
1	20	5	1550
2	20	8	1500
3	20	10	1450
4	30	5	1550
5	30	8	1500
6	30	10	1450
7	40	5	1550
8	40	8	1500
9	40	10	1450

The next step in DOE analysis is determining optimal conditions of the control parameters to give the optimum responses. In this work the response variables to be optimized were BTHE, has to be maximized and B.S.F.C. to be reduced as much as possible. Hence the optimum parameter settings will be those that give maximum values of the BTHE and minimum values of B.S.F.C, HC, and NOx. The optimum settings of the parameters were achieved from the S/N Tables of the control parameters.

2.3 Analysis Method

Experiment is planned according to Taguchi's L9 orthogonal array, which has 9 rows corresponding to the number of testes with 3 columns at three levels as shown in table. The first column of table is assigned to Blend proportion i.e. % of cottonseed biodiesel in diesel, the second to Load, the third column is assigned to Engine Speed. It means a total 9 experiments must be conducted using the combination of levels for each independent factor. This orthogonal array is chosen due to its capability to check the interactions among factors. The experimental results will then transferred in to a Signal to Noise (S/N) ratio. The category the higher-the better for Brake Thermal Efficiency and smaller the better for Brake Specific Fuel Consumption will be used to calculate the S/N ratio for finding optimum set of parameters.

3. RESULTS & ANALYSIS

3.1 Response table for efficiency

Table 3.1 Response table for efficiency

LEVEL1	BLEND	LOAD	SPEED
1	41.72	26.93	39.77
2	40.24	41.16	40.84
3	38.12	51.97	39.41
DELTA	3.59	23.07	1.43
RANK	2	1	3

Result:-
1. As the load increases the speed decreases so the delay time decreases & the efficiency increases.
2. As the blend mixture increases efficiency decrease from DOE.

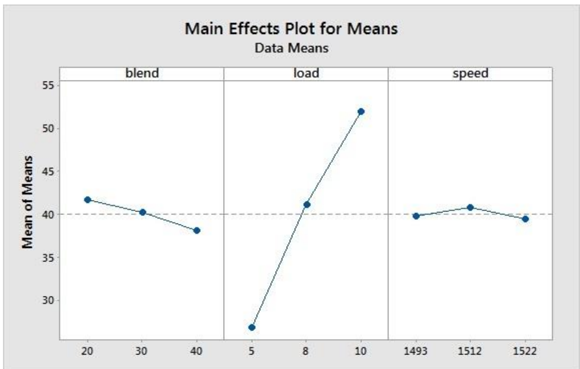
3.3 Orthogonal Array:-

From the below table we can see that 20% blend has the highest efficiency (54.31) & s/n ratio (34.6976) in experiment number 03.
S/N Ratio: - (bigger is the better)

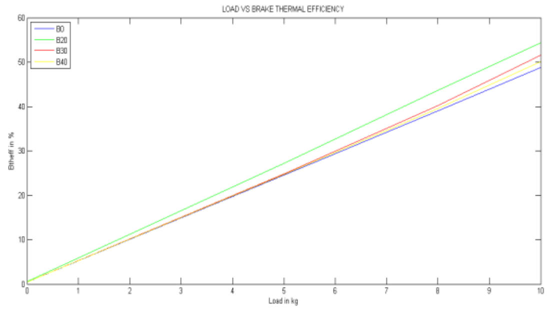
Table 3.2 Optimization for blending mixture

SN	Blend	Load	Speed	Efficiency	S/N Ratio
1	20	5	1522	27.18	28.6850
2	20	8	1512	43.60	32.7897
3	20	10	1493	54.31	34.6976
4	30	5	1512	28.88	29.2119
5	30	8	1493	40.26	32.0975
6	30	10	1522	51.56	34.2463
7	40	5	1493	24.70	27.8539
8	40	8	1522	39.56	31.9451
9	40	10	1512	50.08	33.9933

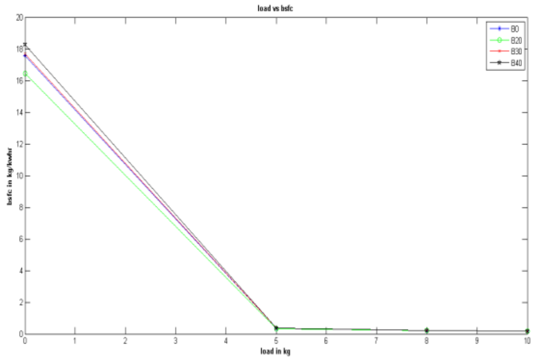
3.4 Comparison Graph



Graph 3.1: Plot for means



Graph 3.2 Variation of BTh efficiency with load



Graph 3.3 Variation of bsfc with load

4. CONCLUSIONS

1 B20 blend is the optimum mixture of cotton seed & orange peel oil in diesel having higher S/N ratio of 34.697.

2 B20 blend shown more overall efficiency of the engine as compared to diesel and has break thermal efficiency higher i.e. 54.31% as compared to other blends.

3 B20 blend gives lower BSFC of the engine is less i.e. 0.16 kg/kwhr as compared to diesel.

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