EXPERIMENTAL STUDY ON CI ENGINE PERFORMANCE USING BIO DIESEL BLENDS

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Abstract -*Internal combustions engines are using petroleum products as a fuel for its running. Due to urbanization and increased population usage of no. of automobiles increased and consumption of petroleum products increased so continuous demand for the energy consumption increased from year to year as a result reserves of petroleum product are depleting in a faster rate. If this trend continuous in the same way entire world may face problem with shortage of petroleum products. Therefore it is necessary to find alternative fuels to be used in the standard internal combustion engine to bridge this gap of increased consumption. Simultaneously it is necessary to improve the combustion engine in terms of fuel efficiency and emissions. As we know so far petroleum based fuels are giving higher efficiency as compared with alternative fuels so to reduce the fuel consumption strict measures to be adopted to control the consumption and also alternative fuels to be developed to mix with the petroleum fuels so that petroleum product reserves will go for longer period and it will meet with increased demand. Otherwise once these fossil fuels are consumed* ***means again it won't exist in nature because of its*** *non-renewable nature. So in this paper focus is given to increase the existence of non-renewable fuels by reducing its consumption with addition of suitable proportions of bio-fuels. In that context importance is given one is to improve the technology to increase the kilometers per hour of unit fuel consumption by improving the suitable modifications in the engine design and other is reducing the fuel consumption by adding renewable blends so petroleum products may last for several years. Here an experimental attempt is being made to reduce the consumption of fossil fuels (petroleum products) by adding bio-diesel blends of small quantities of renewable fuels. It will help to reduce the consumption of petroleum products hence longer period of reserves may be achieved. More over biodiesels are bio degradable, eco-friendly, on toxic and clean burning In this experimentation an attempt to mix the cotton seed oil of different proportions with diesel on a single cylinder diesel engine conducted and various performances are studied in keeping view of reduce the consumption quantity and environmental safety by controlling the exhaust emissions*

Bio-diesel has gained much attention in recent years due to the increasing environmental awareness. It is produced from renewable resources and, more importantly, is a clean burning fuel that does not contribute to the net increase of carbon dioxide.

Key Words: bio-diesel, cotton seed oil, petroleum products, B10, B20, B30, Transesterification

1. INTRODUCTION

Bio-diesel fuel for diesel engines is produced from cotton seed oil, vegetable oil or animal fat by the chemical process of etherification. This paper presents a brief study of diesel engine performance and an overview of biodiesel, including performance characteristics, economics, and potential demand. The performance and economics of biodiesel are compared with that of petroleum diesel.

Rudolph Diesel, the inventor of the Diesel engine experimented with fuels ranging from powdered coal to peanut oil. In the early 20th century and ultimately successes to burn petroleum distillate in diesel engines because it was cheap and plentiful of fuel at that time. In the late 20th century, the cost of petroleum increased in faster rate i.e. in the period of 15 years cost increased 15 times more to the previous cost and at the same rate fuel reserves are depleting, and by the late 1970s there was renewed interest in biodiesel to prolong the availability so Commercial production of biodiesel began in the United States in the 1990.

A variety of bio-liquids can be used to produce biodiesel. The main plants whose oils have been considered as feed stocks for bio fuel are soya bean oil, cotton seed oil, rapeseed oil, palm oil, sunflower oil and jatropha oil. Others in contention are mustard, hemp, castor oil, waste vegetable oil, and in some cases even algae. There is going on research into finding more suitable crops.

2.0 PREPARATION OF BIODIESEL

2.1 process of preparation

The process of converting vegetable oil in to biodiesel Fuel is called Transesterification. Transesterification means taking a triglyceride molecule or a complex fatty acid, neutralizing the free fatty acid, removing the glycerin and creating an alcohol ester. This is accomplished by mixing methanol with sodium hydroxide to make sodium methoxide. This liquid is then mixed into the vegetable oil. After the mixture has settled, glycerin is left on the bottom and methyl esters or bodies is left on top and is washed and filtered. The final product biodiesel Fuel when used directly in a diesel engine will burn up to 75% cleaner than mineral oil Diesel fuel.

Table 1: quantity of Bio-diesel prepared

Notation	Blend name	Fuel quantity(ml)	Bio-diesel quantity (ml)	Diesel quantity (ml)
CSO10	B10	1000	100	900
CSO20	B20	1000	200	800
CSO30	B30	1000	300	700

Fig 1: prepared samples of bio diesel blends

Table 2: Blends of Biodiesel

Biodiesel	Petro diesel	Type
10% Biodiesel	90% Petro diesel	B10
20% Biodiesel	80% Petro diesel	B20
30% Biodiesel	70% Petro diesel	B30
50% Biodiesel	50% Petro diesel	B50
85% Biodiesel	15% Petro diesel	B85

2.2 Major Advantages of bio diesels

- high energy density liquid in form and thus easily to be handled when burned and it emits less soot
- It is neither harmful nor toxic to humans, animals, soil or water
- It is neither flammable nor explosive, and does not release toxic gases
- It is easy to store, transport and handle
- It does not cause damage if accidentally spilt
- Its handling does not require special care to be taken
- It is produced directly by nature and It is a recyclable form of energy
- It does not have adverse ecological effects when used
- It does not contain sulphur it does not cause acid rain and ground water pollution can used in all types of forestry machinery, Lorries, vans, pick-ups, etc. Private cars (no CO2 increase, non inflammable fuel) Mixers, mills, pumps, ventilators, and other stationary industrial and agricultural machinery (no toxic gases or inflammable liquids)

Table 3: comparisons of oil properties

Property	Diesel	CSO	CS10	CS20	CS30
Heating value(kJ/kg)	43000	39648	42308	42116	41834
Carbon residue (% by weight)	<0.35	0.42	0.39	0.38	0.36
Density (g/cc)	0.815	0.850	0.830	0.852	0.862
Kinematic Viscosity(cSt)	3.5	6.0	4.68	4.87	5.05

Table 4: properties of diesel and cotton seed oil

S.NO	Property	Diesel	Cotton seed
1	Higher Calorific	43,000 kJ/kg	39,648 kJ/kg
2	Flash Point	44^0 C	234^0C
3	Fire Point	49^0 C	192^0 C
4	Viscosity	0.278 poise	2.52 poise

3.0 EXPERIMENTAL SETUP

This experimental work is to investigate the performance of single cylinder 4-stroke diesel engine connected to eddy current dynamometer fuelled with cottonseed oil (10%, 20%, 30%) as bio-diesel blends with diesel fuel under different load conditions and constant engine running speed. The performance parameters consists of BP, MFc, SFc, BTHE, BSFC etc. there are several ways of producing bio diesels from bio fuels (edible and non edible oils ,animal fats)

Fig: 2 shows EGR set to the Single cylinder Diesel Engine

3.1. Engine specification:

Table 5: Engine specifications

Type	4-stroke, single cylinder diesel engine
make	kirloskar av-1
rated power	3.7 kw, 1500 rpm
bore and stroke	80 mm×110 mm
compression ratio	16.5:1
cylinder capacity	553 cc
dynamometer	electrical-ac alternator
cylinder pressure	range:2000 psi or 140.000 bars
orifice diameter	15 mm
starting	auto start
cooling	water cooled

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3.2 performance test readings

Table 6: Engine performance test readings at different loads of Pure Diesel

Load (Kg)	T_1 (°c)	T_2 (°c)	T_3 (°c)	T_4 (°c)	T_5 (°c)	T_6 (°c)	Speed (RPM)	Time (Sec)
1	33	31	87	34	33	34	1543	100
2	29	31	162	37	36	37	1523	70
3	29	32	210	39	38	40	1498	56

Table 7: Engine Performance test Readings with B10

Load (Kg)	T_1 (°c)	T_2 (°c)	T_3 (°c)	T_4 (°c)	T_5 (°c)	T_6 (°c)	Speed(RPM)	Time (Sec)
1	30	32	82	35	34	35	1540	106
2	30	33	152	38	37	38	1520	71
3	30	33	209	40	39	41	1496	56

Table 8: Engine Performance test Readings with B20

Load (Kg)	T_1 °c	T_2 °c	T_3 °c	T_4 °c	T_5 °c	T_6 °c	Speed RPM	Time (Sec)
1	34	35	210	41	41	42	1533	108
2	34	35	207	42	41	42	1519	72
3	34	35	232	43	42	44	1492	58

Table 9: Engine Performance test Readings with B30

Load (Kg)	T_1 °c	T_2 °c	T_3 °c	T_4 °c	T_5 °c	T_6 °c	Speed RPM	Time (Sec)
1	34	34	116	37	36	37	1530	105
2	34	34	154	39	39	40	1511	71
3	34	35	219	41	41	43	1486	57

4.0 FORMULAYS USED IN PERFORMANCE CALCULATIION:

4.1 Brake power (BP): it is the power available at the engine shaft

$$BP = \frac{V \times I}{1000 \times 0.85} \text{.........KW}$$

Where, V=voltage in volts,
I=current in amps,
0.85= generator efficiency,
The difference between I.P. and B.P. is called Frictional power (FP),
FP = IP – BP

4.2 Mass of fuel consumed (mfc)

$$mfc = \frac{X \times \rho \times 3600}{1000 \times T} \text{.........kg/hr}$$

Where, X=Burette reading in cc,
ρ=Density of fuel in gram /cc, and
T=Time taken in seconds.

4.3 Specific fuel consumption (sfc)

$$Sfc = \frac{m_{fc}}{BP} \text{.........kg/kwhr}$$

4.4 Volumetric Efficiency (η_V)

$$\eta_V = \frac{V_a}{V_s} \times 100 \text{ ....\%}$$

4.5 Actual volume of air sucked in to the cylinder (V_a)

$$V_a = C_d \times A\sqrt{2gH} \times 3600 \text{ ....} m^3/hr$$

Where, $H = \frac{h}{1000} \times \frac{\delta w}{\delta a}$ meter of water,

h = Manometer reading in mm,
A= Area of orifice in square meter= $\pi d^2/4$,
d = Orifice diameter in meter=0.015m,
C_d= Co-efficient of discharge=0.62, and
$\frac{\delta w (density of water)}{\delta a (density of air)} = \frac{1000\ kg/m^3}{1.193\ kg/m^3}$

4.6 Swept volume (V_S)

$$V_S = \frac{\pi d^2}{4} \times L \times \frac{N}{2} \times 60 \text{ ....} m^3/hr$$

Where,d= Diameter of bore in meter = 0.08m,
L= Length of stroke in meter = 0.11m,
and N=Speed of the engine in rpm.

4.7 Brake thermal (OR) Overall Efficiency (η_{bth})

$$\eta_{bth} = \frac{BP \times 3600}{m_{fc} \times cv} \times 100 \text{.........\%}$$

Where, BP = Brake power in KW,
m_{fc}= Mass of fuel consumed in Kg/hr, and

CV= Calorific value of diesel = 42500 kJ/kg.

4.8. Indicated Thermal Efficiency:

$$\eta_{Ith} = \frac{IP}{\dot{m}mfc \times CV} \times 100 \text{.........\%}$$

IP= Indicated power in KW,
m_{fc}= Mass of fuel consumed in Kg/Hr, and
CV= Calorific value of diesel = 42500 kJ/kg.

4.9 Mechanical Efficiency:

$$\eta_{mech} = \frac{B.P}{I.P} \text{.........\%}$$

BP = Brake power in KW,
IP= Indicated power in KW.

5.0 PERFORMANCE EVUALATION -RESULTS

The performance of engine is calculated by using formulae presented in section 4.1 to 4.9 the obtained results are presented in following tables from table No.10 to 13 the calculating steps followed are same for every sample and calorific values, specific gravity density of each fuel should be considered and tabulated.

5.1 Performance values of pure diesel

Calorific Value = 42500 KJ/Kg, Frictional power = 1.30 KW, Density = 0.82 Kg/m^3.

Table 10: calculated engine performances for pure diesel

Load (Kg)	Speed RPM	B P (kW)	M_{fc} Kg/hr	S_{fc} Kg/kWh	I P (kW)
1	1543	1.16	0.53	0.45	2.46
2	1523	2.62	0.78	0.30	3.92
3	1498	3.44	1.05	0.30	4.74

Load (Kg)	Speed (RPM)	η_{bth} (%)	η_{Ith} (%)	η_{Mech} (%)	η_{Vol} (%)
1	1543	18.50	39.24	47.15	67.20
2	1523	28.19	42.19	66.83	68.33
3	1498	27.71	38.09	72.57	69.47

5.2 Performance values of B10

Calorific Value = 41900 KJ/Kg, Frictional power = 1.32 KW, Density = 0.8225 Kg/m^3.

Table 11: calculated engine performances for bio-diesel blend B10

Load (Kg)	Speed (RPM)	B P (kW)	M_{fc} Kg/hr	S_{fc} Kg/kWh	I P (kW)
1	1540	1.14	0.55	0.482	2.46
2	1520	2.59	0.822	0.3173	3.91
3	1496	3.40	1.04	0.3058	4.72

Load (Kg)	Speed (RPM)	η_{bth} (%)	η_{Ith} (%)	η_{Mech} (%)	η_{Vol} (%)
1	1540	17.8	38.429	46.34	61.08
2	1520	27.07	40.86	66.24	61.88
3	1496	28.08	38.99	72.033	62.87

5.3 Performance values of B20

Calorific Value = 41460 KJ/Kg, Frictional power = 1.33 KW, Density = 0.826 Kg/m^3.

Table 12: calculated engine performances for bio-diesel blend B20

Load (Kg)	Speed (RPM)	B P (kW)	M_{fc} Kg/hr	S_{fc} Kg/kWh	I P (kW)
1	1533	1.12	0.54	0.4821	2.45
2	1519	2.56	0.821	0.3207	3.89
3	1492	3.371	1.01	0.270	4.70

Load (Kg)	Speed (RPM)	ηbth (%)	ηIth (%)	ηMech (%)	ηVol (%)
1	1533	18.00	31.395	45.714	67.72
2	1519	27.075	41.141	65.809	68.87
3	1492	28.98	40.406	71.72	70

5.4 Performance values of B30

Calorific Value = 40870KJ/Kg, Frictional power = 1.34 KW, Density = 0.827 Kg/m^3.

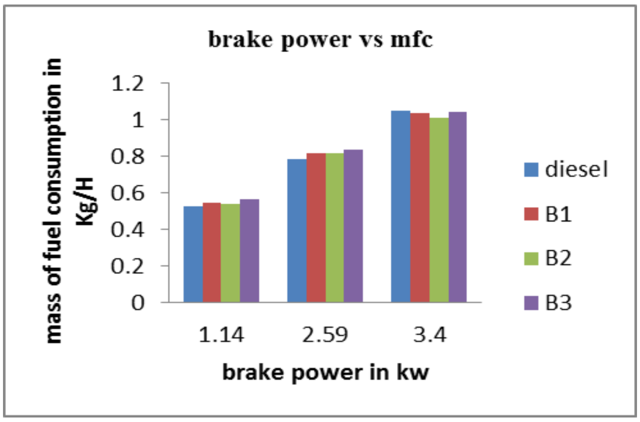
Table 13: calculated engine performances for bio-diesel blend B30

Load (Kg)	Speed (RPM)	B P (kW)	M_{fc} Kg/hr	S_{fc} Kg/kWh	I P (kW)
1	1530	1.10	0.567	0.5154	2.49
2	1511	2.54	0.838	0.3299	3.88
3	1486	3.34	1.044	0.312	4.68

Load (Kg)	Speed (RPM)	ηbth (%)	ηIth (%)	ηMech (%)	ηVol (%)
1	1530	17.08	38.68	44.17	77.77
2	1511	26.69	40.78	65.46	78.73
3	1486	29.16	39.48	71.36	80.08

6.0 ENGINE PERFORMANCE CURVES

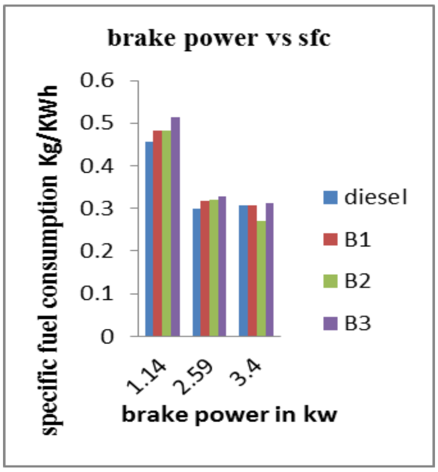
6.1 Brake power on X-axis and Mass of Fuel Consumption on Y-axis



Graph 1: mass of fuel consumption Vs brake power of a diesel and its blends

Graph 1: shows the variation in mass of fuel consumption with the change in brake power. For all blends and diesel tested, MFC increased with increase in brake power. Brake power vs mass of fuel consumption graphs are drawn at different brake power and observed the pure diesel mass of fuel consumption is low compared with the biodiesel blends.

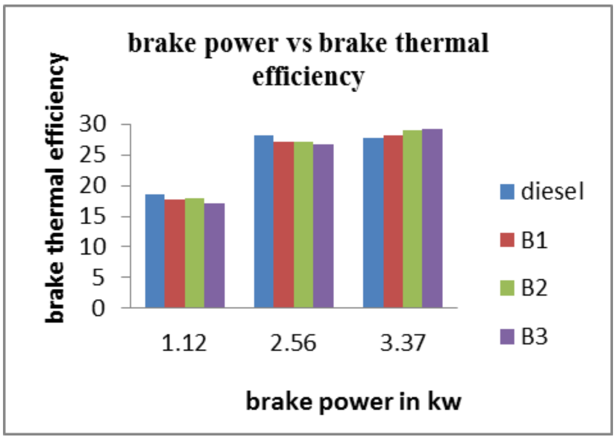
6 .2 Brake power on X-axis and Specific Fuel Consumption on Y-axis



Graph .2: specific fuel consumption Vs brake power of a diesel and its blends

Graph 2: shows the variation in brake specific fuel consumption with the change in brake power. For all blends and diesel tested, SFC decreased with increase in brake power. In case of biodiesel mixtures, the BSFC values were determined to be higher than that of diesel fuel. This trend was observed owing to the fact that biodiesel mixtures have a lower heating value than doe's diesel fuel, and thus more biodiesel mixtures is required for the maintenance of a constant power output. It is well known that brake specific fuel consumption is inversely proportional to the brake thermal efficiency.

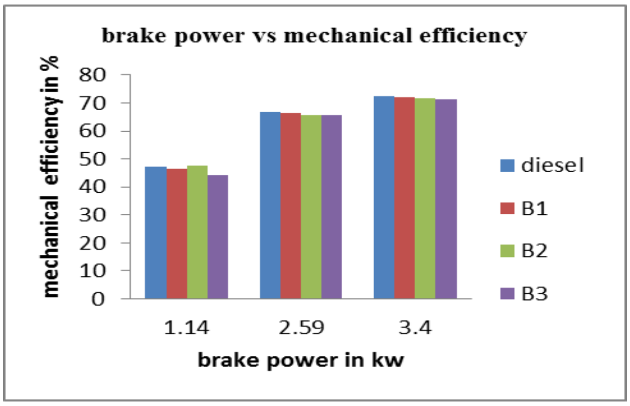
6.3 Brake power on X-axis and Brake Thermal Efficiency on Y-axis



Graph 3: Break thermal efficiency Vs brake power of a diesel and its blends.

Graph 3: shows the variation in brake thermal efficiency (BTE) with the change in brake power. In all cases, brake thermal efficiency increases with an increase in brake power. It is also observed that diesel exhibits slightly higher thermal efficiency at most of the loads than blends of cotton seed oil (biodiesel). The factors like lower heating values and higher viscosity of the biodiesel may affect the mixture formation process and hence result in slow combustion hence reducing the brake thermal efficiency. The molecules of biodiesel contain some amount of oxygen, which take part in the combustion process. Test results indicate that when the mass percent of fuel oxygen exceeds beyond a certain limit, the oxygen losses its positive influence on the fuel energy conversion efficiency in this particular engine. So the brake thermal efficiency of diesel is more than that of biodiesel blends

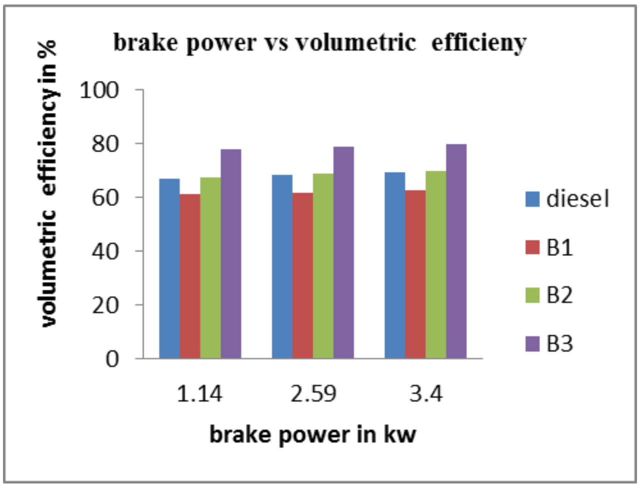
6.4 Brake power on X-axis and Mechanical Efficiency on Y-axis



Graph 4: mechanical efficiency Vs brake power of a diesel and its blends.

Graph 4 shows the variation in Mechanical efficiency with the change in brake power. For all blends and diesel tested, Mechanical efficiency increases with increase in brake power, Mechanical efficiency decreasing with increasing blend concentration

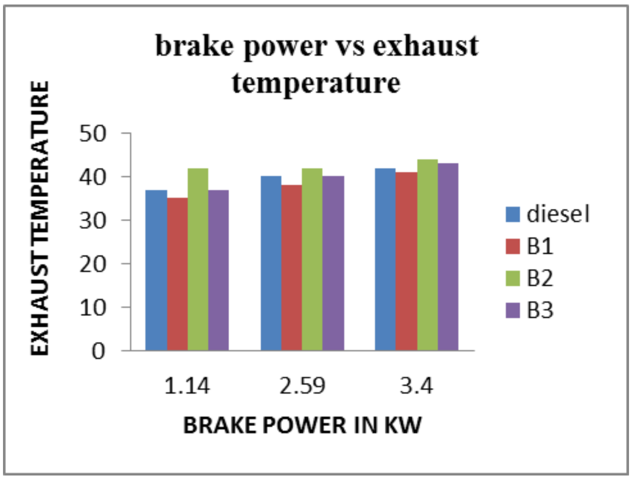
6 .5. Brake power on X-axis and Volumetric Efficiency on Y-axis



Graph 5: volumetric efficiency Vs brake power of a diesel and its blends.

Graph. 5. Illustrates the variation in volumetric efficiency with the change in brake power. For all blends and diesel tested, volumetric efficiency increases with increase in brake power, volumetric efficiency increases with increasing blend concentration.

6.6. Brake power on X-axis and Exhaust Temperature onY-axis



Graph 6: exhaust temperature Vs brake power of a diesel blends.

Graph6: shows the variation in exhaust gas temperature (EGT) with the change in brake power. The biodiesel contains some amount of oxygen molecules in the ester form. It is also taking part in the combustion process. When biodiesel concentration is increased, The exhaust gas temperature increases by a small value. The exhaust gas temperature increases with increase in brake power. The reason of EGT being more in the case of biodiesel blends is the presence of more oxygen atoms in the biodiesel. So, the exhaust gas temperature increases and it increases with increase in brake power. As the load on the engine increases, more fuel is burnt. So exhaust gas temperature increases continuously with rise in brake power.

7.0 OBSERVATIONS

7.1 Exhaust temperature: Exhaust gas temperature increases with increase in load for diesel as well for all combination of blends. As the load increase fuel air ratio increases and hence the operating temperature increases which results in higher exhaust gas temperature. For biodiesel operations the exhaust gas temperature is increased at blend 2 compare to the diesel, blend 1 and blend 3. In biodiesel operation the combustion is delayed due to higher fire point. As the combustion is delayed, injected biodiesel fuel particles may not get enough time to burn completely during before top dead center, hence some fuel mixtures tends to burn during the early part of expansion, consequently after burning occurs and hence increase in the exhaust temperature.

7.2 Specific fuel consumption and Thermal efficiencies: Cotton seed oil can be directly used in diesel engine without any modifications. As the fuel concentration increases, viscosity gradually increases thereby the mass consumption decreases with decrease in brake power output. Form the observed experimental results we can conclude that specific fuel consumption is increases with increasing the blend concentrations. And also brake thermal efficiency is slightly decreases and also volumetric efficiency increases with blend concentration.

8. FUTURE SCOPE

1. The biodiesel fuels produced less smoke than diesel under similar engine operating conditions, probably because palm oil contains oxygen which helps the combustion in the cylinder.

2. The biodiesel and reference fuels provided similar combustion pressure patterns at low and medium engine loads, suggesting that the biodiesels had no adverse effect in terms of knocking.

3. The biodiesel fuels lowered the premixed combustion of heat release because of the lower volatility.

So most diesel engines are being is converted to pure plant oil operation, including advanced TDI versions, and as such the technology much be counted as available on a broad basis. One of the main suppliers of conversion equipment (Elsbett in Germany) also sells an engine specifically designed for PVO operation. Additionally the tractor manufacturer Deutz - Fahr markets a tractor specifically adapted for PVO operation as part of a market introduction program
Single tank conversions have been developed, largely in Germany, which have been used throughout Europe. These conversions are designed to provide reliable operation with rapeseed oil that meets the German rapeseed oil fuel standard DIN 51605. Modifications to the engines cold start regime assist combustion on startup and during the engine warm up phase. Suitably modified indirect injection (IDI) engines have proven to be operable with 100% PPO (pure plant oil) down to temperatures of −10°C. Direct injection (DI) engines generally have to be preheated with a block heater or diesel fired heater. The exception is the TDI (Turbocharged Direct Injection) engine for which a number of German companies offer single tank conversions. For long term durability it has been found necessary to increase the oil change frequency and to pay increased attention to engine maintenance.

9.0 CONCLUSIONS

The performance and emission characteristics of a single cylinder four stroke diesel engine with cotton seed oil as fuel are experimentally investigated and compared with diesel. It is observed that, the viscosity and density of the blend goes up with increased percentage of CSO. However its calorific value is low enough and it gives reduced energy per liter as the CSO percentage increases. The salient observations are,

- Cotton seed oil + diesel can be directly used in diesel engine without any engine modification.
- Specific fuel consumption increases with an increase in biodiesel concentration. SFC is increasing atB30 by 12.6% at 1 KW load compared to diesel fuel.
- Volumetric Efficiency increases with biodiesel concentration. The increase in volumetric efficiency of biodiesel blends is 13% higher than pure diesel, irrespective bio-diesel concentration.
- Mechanical Efficiency for bio-diesel blends is lower than the pure diesel.

- Brake thermal efficiency increases with increasing bio-diesel concentration.
- CO_2 emissions decreased with increasing blend concentration.

In general all emissions are observed to be on the lower side for all the bio-diesel blends as compared to pure diesel.

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