ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

PERFORMANCE AND EMISSION TEST ON RUBBER SEED OIL BLENDED WITH DIESEL AS AN ALTERNATIVE FUEL IN COMPERSSION IGNITION ENGINE

PRAKASH.R, M.E (THERMAL ENGINEERING)
Department of MECHANICAL ENGINEERING
J.J.COLLEGE OF ENGINEERING AND TECHNOLOGY, Tiruchirappalli-620009,
Tamil Nadu, India.

SANTHOSH PRAKASH.A, M.E, Assistant Professor
Department of MECHANICAL ENGINEERING
J.J.COLLEGE OF ENGINEERING AND TECHNOLOGY, Tiruchirappalli-620009,
Tamil Nadu, India.

ABSTRACT

The present work has been investigated experimentally and compared the effects of Vegetable Oil and diesel fuel blends on the performance and emissions of a single cylinder DI-DIESEL engine system. An attempt was made to determine the optimum percentage of Rubber Seed Oil that gives lower emission at optimal percentage of exhaust gas recirculation. A matrix of experiments is conducted for observing the effect of different quantities of EGR on exhaust gas temperatures and opacity with Biodiesel blends on diesel engine. The rubber seed oil has a lesser cetane number than diesel, which prevented the 100% replacement of diesel with the rubber seed oil in the diesel engines.The mixing proportions are B25%, B50%, B75% with varying percentage of exhaust gas recirculation. The analysis focuses on all regulated exhaust pollutants, i.e. Opacity, Nitrogen Oxides (NOx), Carbon monoxide (CO), Carbon-di-oxide (CO2) and unburned hydrocarbons (HC). Performance analysis such as Brake power (BP), Brake Specific Fuel Consumption (BSFC) and Brake Thermal Efficiency (BTE) are considered for experimental investigation.

Keywords: Biodiesel Fuel, Brake Specific Fuel Consumption, Exhaust Emissions, Diesel Engine, Direct Injection, Transesterification, Rubber Seed (Hevea Brasiliensis)

1. INTRODUCTION

The large increase in industrialization and motorization in recent years has resulted in great demand for petroleum products. Petroleum based fuels are obtained from limited reserves. The price of conventional fossil fuel is too high and has added burden on the economy of the importing nations. With crude oil reserves estimated to last only for few decades, there has been an active search for alternate fuels. Experimental investigations revealed that local fuels such as coconut, palm and rubber seed oils are found to be alternative fuels to diesel in compression ignition engine .These oils can be used directly without any major modifications in the compression ignition engines.The aim of this paper is to study the suitability of locally available vegetable oil

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

based biofuels in Kerala rubber seed oils as substitutes to conventional diesel fuel in diesel engines.

1.1 Benefits of an Bio-fuels

- Renewable and alternative energy sources.
- Easy to develop and use.
- Low-cost and not a-very-high-tech route, therefore, can be readily implemented, environmentally safer and compatible.
- Biodiesel provides more lubrication than petroleum diesel.
- Biodegradable, non-toxic and free of sulphur and aromatic compounds, therefore, no SOx emissions.
- Bio-fuel is an ideal synergistic partner for oxidation catalytic converter and reduces CO2 emissions by 78 % when compared to conventional diesel fuel.
- Bio-diesel is an oxygenated fuel with O2 content of about 10 % and therefore gives better emission characteristics in term of CO, Hydrocarbons, and Particulate matter.
- Also, Bio-diesel has a higher Cetane number, ensuring low noise and smooth running, during engine combustion.
- In addition, the by-product resulting after extracting bio fuel is an excellent source of nitrogen rich organic fertilizer.

1.2 Rubber Seed Feed Stock For Bio Diesel Production:

Natural rubber producer in the world are Thailand (35%), Indonesia (23%), Malaysia (12%), India (9%), and China (7%). Normal seed production yields vary from 70 to 500 kg/ha/year. while the annual rubber seed production potential in India is about 150 kg per hectare. Ramadhas et al. demonstrated that methyl esters of rubber seed oil could be successfully used in existing diesel engines without any modifications. Lower concentrations of biodiesel blends improved thermal efficiency. At higher concentrations of biodiesel in the blend, there was a reduction of smoke density in exhaust gas .Rubber seed oil is oil extracted from the seeds of rubber trees. Rubber seed as a waste product from rubber plantations, Rubber (heveabrasiliensis) tree starts to bear fruits at four years of age. Each fruit contain three or four seeds, which fall to the ground when the fruit ripens and splits. Each tree yields about 800 seeds (1.3 kg) twice a year.

1.2.1 Economics of Biodiesel

The major economic factor to consider for input costs of biodiesel production is the feedstock (price of seed, seed collection and oil extraction, transport of seed and oil), which is about 75–80% of the total operating cost. Other important cost related factors are labour, methanol and catalyst for biodiesel conversion for straight vegetable oil, which must be added to the feedstock. Cost recovery will be through sale of oil cake and of glycerol (Mulugetta,2009). The volatile oil prices due to increased demand have necessitated for continuous research and development into the biodiesel sector so as to increase the production of biodiesel of suitable quality and at reasonable price so that it can compete with diesel fuel.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

1.2.2 Production of Rubber seed oil

The rubber seeds were cracked and the kernels (52.5% of seed weight) were dried in the oven at 100°C for 20hours. The crude rubber seed oil was extracted from kernels by hydraulic press machine and was about 10% of seed weight. The extracted crude rubber seed oil usually contains sediment of kernel and moisture. The crude rubber seed oil should be cleared from adulterants before the acid esterification process in order to avoid the imperfection of the process.

The rubber seed oil varies in color from light yellow to brown, depending on the Free Fatty Acids (FFA) content, yellow being on the lower side. Rubber seed oil extracted and used for this analysis had an acid value of 35 mg KOH/g, which is equivalent to 17.5% FFA. The presence of high FFA hinders the transesterification process by single stage using a base catalyst due to its preference for saponification thereby forming soap. Hence the amount of FFA must be reduced to its minimum by acid esterification before alkaline esterification.

2. EXPERIMENTAL SETUP

2.1 TEST ENGINE

Test engine used in the experiments is a single cylinder four-stroke, naturally aspirated, constant speed compression ignition engine. Engine was tested at a rated speed of 1500rpm. The exhaust gas was sent to the smoke meter and gas analyzer to measure smoke intensity, CO, CO_2, etc. The engine was coupled to a generator set and loaded by electrical resistance to apply different engine loads. The specification of the engine and generator is demonstrated in table, the voltage, current and power developed by the engine was directly displayed on the control. The readings taken during each set of experiments was used for the calculation of brake specific consumption, thermal efficiency, and other engine characteristics.

2.2 TEST ENGINE SETUP

Figure. 2.2.1 Photo View Of Test Engine Setup

2.3 ENGINE SCHEMATIC DIAGRAM

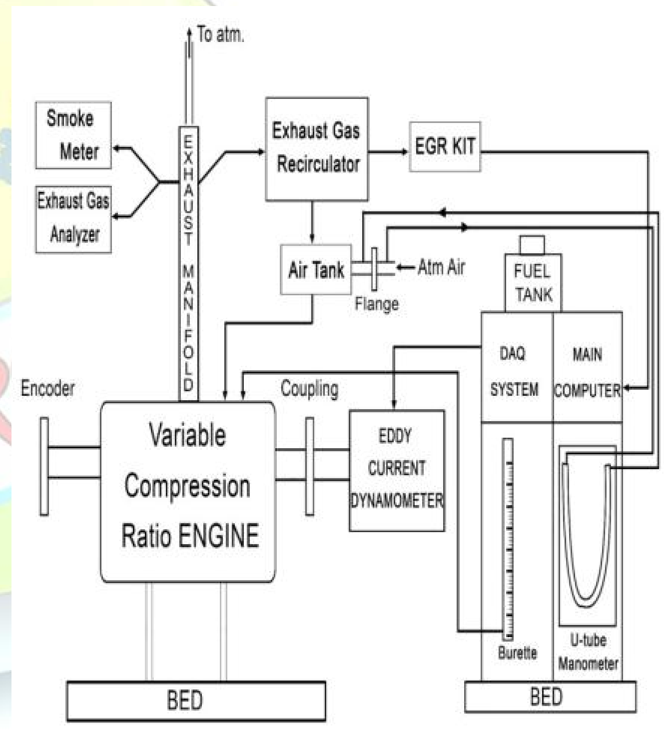


Fig. 2.3.1 Schematic View Of Engine Setup

The pressures versus crank angle diagrams were directly displayed on the digital storage oscilloscope (DSO). The engine speed was checked by a tachometer. The unburnt hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

(NO_x) emission were measured by AVL exhaust gas analyzer.

2.4 TEST ENGINE SPECIFICATION

Table 2.4.1 Specification of IC research engine

Engine make	Kirloskar model AV1
Fuel	H.S. Diesel Oil
No. of cylinders	1
No. of Strokes	4
Cylinder Diameter	0.0875m
Stroke length	0.11m
Engine power	5.2 kW (7hp)
Compression ration	17.5:1
RPM	1500
Type of starting	Crank starting
Air Measurement Orifice Diameter	0.02m
Eddy current dynamometer Dynamometer arm length	0.195m
Cooling technique	Water cooled

3. PERFORMANCE AND EMISSION TEST

Engine performance is an indication of the degree of success with which it does its assigned job *i.e.,* conversion of chemical energy contained in the fuel into useful work.

In evaluation of engine performance certain basic parameters are chosen and effect of various operating conditions and modifications on these parameters are studied.

3.1Basic performance parameters

3.1.1 Power and mechanical efficiency
3.1.2Mean effective pressure
3.1.3 Volumetric efficiency
3.1.4 Thermal efficiency
3.1.5 Specific fuel consumption

3.1.1 Power and mechanical efficiency

Indicated power. The total power developed by combustion of fuel in the combustion chamber is called indicated power.

$$I.P.=BP+FB\ \ kW$$

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

Brake power. The power developed by an engine at the output shaft is called brake power.

$$B.P.=\frac{2\pi ReNT}{60\times1000}kW$$

Mechanical efficiency. The ratio of brake power and indicated power is called mechanical efficiency = B.P. / I.P.

3.1.2 Mean effective pressure

It is defined as the hypothetical pressure which is thought to be acting on the piston throughout the power stroke. If it is based on indicated power it is indicated mean effective pressure. If based on brake power it brake mean effective pressure.

3.1.3 Volumetric efficiency

Table 3.1 Specification of IC research engine

S.No.	Parameters	Specifications
1	Engine type	Single cylinder vertical water cooled 4 stroke Diesel Engine
2	Power	5.2 Kw (7HP)
3	Rated speed	1500 rpm
4	Cylinder bore	87.5 mm
5	Stroke length	110 mm
6	Connecting rod length	195 mm
7	Compression ratio	17.5

It is defined as the ratio of actual volume of the charge drawn in during the suction stroke to swept volume of the piston.

$$\text{volumetric efficiency}=\frac{v_a}{v_s}\times 100$$

3.1.4 Thermal efficiency

It is the ratio of indicated work done to energy supplied by the fuel.

$$\text{Indicated thermal efficiency}=\frac{I.P.}{Fc\times C_v}\times 100$$

$$\text{Brake thermal efficiency}=\frac{B.P.}{Fc\times C_v}\times 100$$

3.1.5 Specific fuel consumption (SFC)

It is the mass of the fuel consumed per kW developed per hour, and is a criterion of economic power production.

$$SFC=\frac{Fc}{B.P.}\ kg/kWh.$$

3.2 Internal combustion research engine

The performance tests were carried out in IC research engine for various proportions of waste plastic oil diesel blends. The specifications of the research engine are given in the table.

3.3 Data collection

There are five test fuels were used during performance test includes 100 % diesel, 25 % RSO blend with diesel, 50% RSO blend with diesel, 75 %RSO blend with diesel, 100% RSO blend with diesel. The following tables shows the obtained data's from performance tests for various RSO diesel blends such as Brake power, Indicated power, Mechanical efficiency, brake mean effective pressure, brake thermal

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

efficiency, indicated thermal efficiency, specific fuel consumption.

3.4 Types of Emission

1. Carbon monoxide (CO)
2. Hydrocarbons (HC)
3. Carbon dioxide (CO_2)
4. Oxygen (O_2)
5. Nitrogen oxide (NO_X)

4. RESULT AND DICUSSION

From the observations, the data for conventional diesel and biodiesel were obtained and compared. With the help of these data, the characteristic curves were plotted and compared. Brake thermal efficiency shows a tendency to increase with increase in load. This is due to the reduction in heat loss and is leading to the increase in output power. The mixing of biodiesel with diesel oil yields to high thermal efficiency curves. The thermal efficiency of the engine is improved withincreasing concentration of the biodiesel in the blend. The reason may be the additional lubricating effect shown by the rubber seed oil and the biodiesel. Alsothe molecules of biodiesel (i.e. methyl esters of the oil) contain some amount of oxygen, which takes part in the combustion process.

4.1 Brake thermal efficiency

Brake thermal efficiency is the ratio of brake power output to power input. Differences in thermal efficiency were small at low load values, but became more obvious at higher load. The variation of brake thermal efficiency with brake power is shown in Figure7.1. It can be observed from the figure that the thermal efficiency is 28.67% at 5.19kw brake power for diesel.

The maximum BTE obtained for diesel, B25, B50, B75 and B100 is 28.99%, 26.69%, 27.08% and 23.79% respectively and with diesel it is 29.92% with respectively at 5.19kw brake power full load. It is observed that the RSO-diesel blends showed poor thermal efficiency compared to diesel because of high viscosity and low volatility and leads to poor atomization and vaporization of the RSO fuel. The BTE of B25 is higher compared with all RSO-diesel blends. This may be due to improved viscosity and density of B25 when blend with diesel resulting in better combustion and hence increased brake thermal efficiency.

4.2 Indicated thermal efficiency

The ratio between the indicated power output of an engine and the rate of supply of energy in the steam or fuel, the amount of power developed in the cylinder, can also be considered as the power exerted on the piston. Actually fuel power is converted into indicated power, but there are various loss like heat loss from cylinder walls, by cooling water, heat lost in exhaust gas. Hence this IP is lower than FP.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

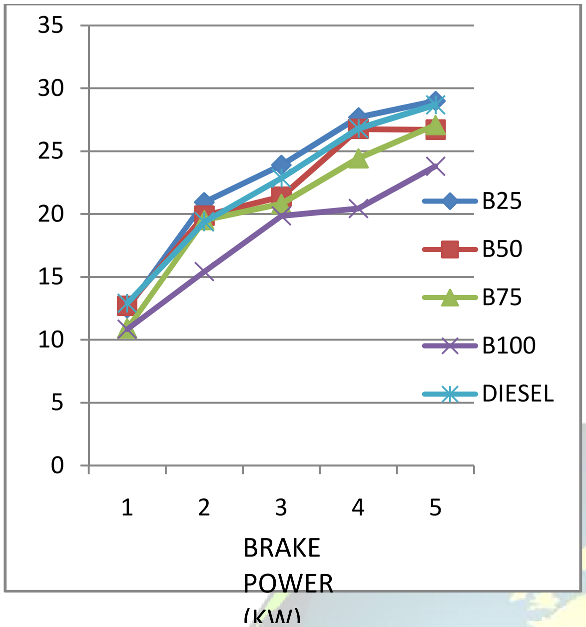


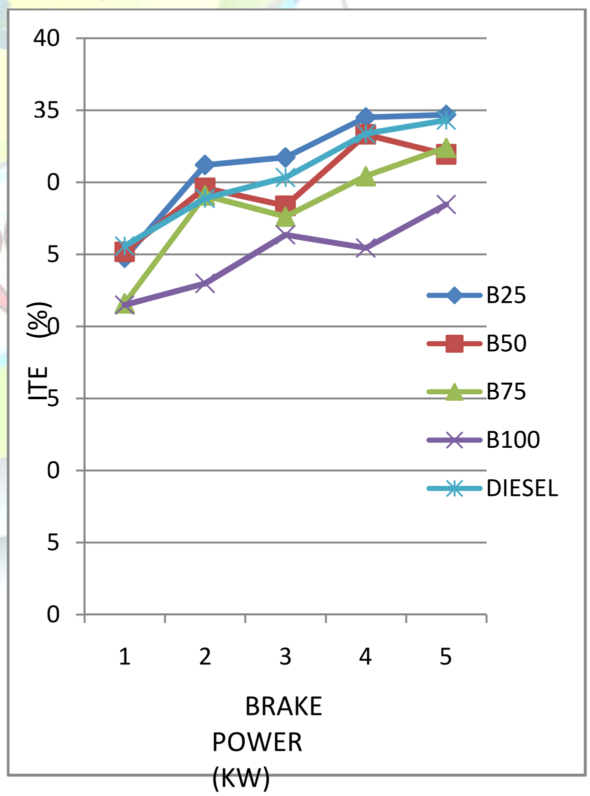
Figure 4.1 Brake thermal efficiency against load

The variation of indicated thermal efficiency with load is shown in Figure 4.2. It can be observed from the figure that the indicated thermal efficiency is 34.30 % at 5.19kw brake power for diesel. When the engine is fueled with RSO diesel blends such as 25% RSO, 50% RSO, 75% RSO, and 100% RSO, it gives the thermal efficiency of 34.67%, 31.93%, 32.39% and 28.46 % respectively at 5.19kw brake power. It is also observed that indicated thermal efficiency is also higher for 25% blends and it is slightly lower for50%, 75% and 100% RSO Diesel blend when compared to pure diesel.

4.3 Brake specific fuel consumption

Brake specific fuel consumption is the rate of fuel consumption divided by the rate of power production. Brake specific fuel consumptions descend from lower to higher load level. It is related with brake thermal efficiency.

The variation of brake specific fuel consumption with load is shown in Figure4.3. It can be observed from the figure that the brake specific fuel consumption is 0.282 kg/kWh at 5.19kw brake power for diesel. When the engine is fueled with RSO diesel blends such as 25% RSO, 50% RSO, 75% RSO, and 100% RSO, its brake specific fuel consumption is 0.2791 kg/kWh, 0.3032 kg/kWh, 0.2988 kg/kWh and 0.3401 kg/kWh respectively at 5.19kw break power. It is also noted that the brake specific fuel consumption is decreased for 25 % RSO Diesel blends and it is slightly increase for50%, 75% and 100% RSO Diesel blend when compared to pure diesel.



ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

Figure 4.2 Indicated thermal efficiency against load

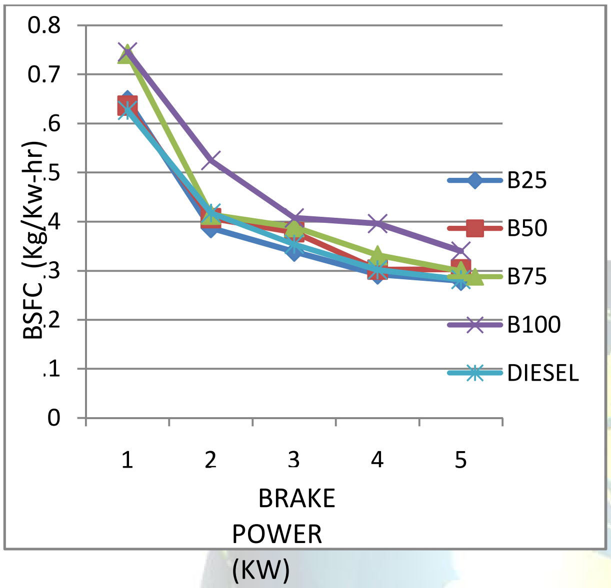


Figure 4.3 Brake specific fuel consumption against brake power

4.4 Indicated specific fuel consumption

Specific fuel consumption is the ratio that compares the fuel used by the engine to the amount of power the engine produces.

The variation of indicated specific fuel consumption with load is shown in Figure4.4. It can be observed from the figure that the indicated specific fuel consumption is 0.236 kg/kWh at 5.19kw brake power for diesel. When the engine is fueled with RSO diesel blends such as 25% RSO, 50% RSO, 75% RSO, and 100% RSO, its indicated specific fuel consumption is 0.2334 kg/kWh, 0.2534 kg/kWh, 0.2498 kg/kWh and 0.2844 kg/kWh respectively at 5.19kw break power. It is also noted that the indicated specific fuel consumption is decreased for 25 % RSO Diesel blends and it is slightly increase for50%, 75% and 100% RSO Diesel blend when compared to pure diesel.

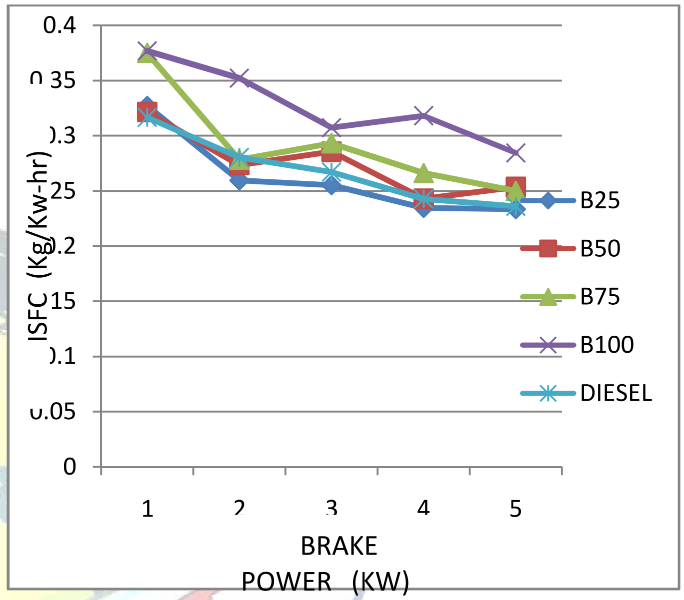


Figure 4.4 Indicated specific fuel consumption against brake power

4.5 Carbon monoxide (CO)

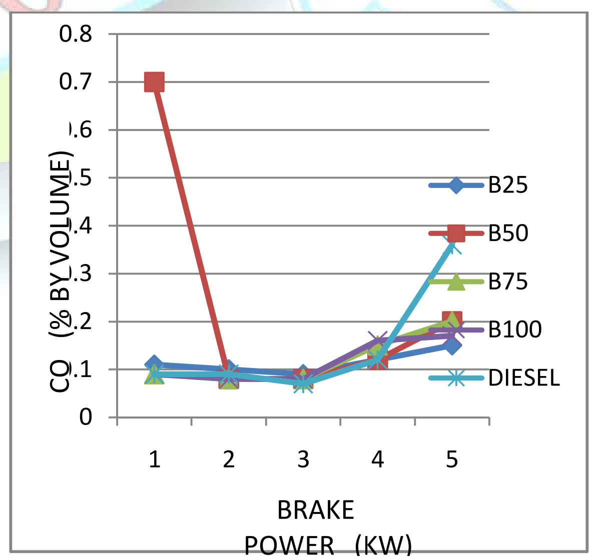


Figure 4.5 Carbon monoxide (CO) against brake power

The variations in carbon monoxide emission with brake power for all the tests fuels are presented in Figure7.5. It can be observed from the figure that carbon monoxide (CO) is 0.36% at 5.19kw brake power for diesel. However when the engine is fuelled with RSO-diesel blends such as 25% RSO, 50% RSO, 75% RSO, and 100% RSO, it gives the carbon monoxide (CO) of 0.15%, 0.2%, 0.2%, and 0.17% respectively at 5.19kw brake power. The higher viscosity of B100 results in poorer combustion and higher CO emission especially at higher load levels. It is also observed that carbon monoxide (CO) is lower for 25%, 50%, 75% and 100% RSO Diesel blends when compared to pure diesel.

5.CONCLUSION

5.1. OVERALL RESULTS

In this study, the production of methyl ester from crude rubber seed oil has been successfully performed. The acid esterification-alkaline transesterification reaction was adopted.. The first step of the process is to reduce FFA content in vegetable oil by esterification with methanol and acid catalyst. The second step is transesterification process, in which triglyceride (TG) portion of the oil reacts with methanol and base catalyst to form ester and glycerol. Various blends of biodiesel, diesel fuel are tested in diesel engine and its performance emission characteristics are analyzed. The main conclusions from this research can be summarized as follows:(i) BSFC for B5 fuel was comparable to that of diesel fuel. The BSFC was significantly higher (23%) than for diesel fuel. Brake thermal efficiency of B5 blend was better than B100 but still less than diesel, due to the lower calorific value of Rubber Seed Biodiesel than diesel. (ii)The B5 blend produced lower exhaust emissions including CO, THC and smoke opacity. Emissions for B100 were significantly higher than diesel (20.83% CO, 27. opacity after endurance test) because of poorer atomization due to high viscosity and poorer combustion due to the low heating value of RSB. According to results of CO and smoke emissions, it appears that the most favorable working condition of B100 fuel is at 200 kPa and 1500 rpm due to reduction of those emissions. (iii) Rubber Seed Biodiesel reduced wear of fuel-contact engine components due to its better lubricity. (iv)Pure Rubber Seed Biodiesel and B5 reduce deposits on the cylinder head but Rubber Seed Biodiesel increases deposits on the piston due to the high concentration of unsaturated fatty acids in the carbon chain. (v) B5 does not significantly affect the lubricating oil viscosity. Overall the results indicate that Rubber Seed biodiesel can be used as a partial substitute for diesel fuel. A 5 % blend of Rubber Seed Biodiesel with diesel fuel can be used to fuel diesel engines providing comparable performance, reduced emissions, wear reduction of engine components and neutral effect on lubricating oil. (vi)No significant engine modifications are required.

6.REFERENCES

1. Abu-Qudais.M, Haddad.O, Qudaisat.M(2000), “The effect of alcohol
2. Fumigation on diesel engine performance and emission” Energy

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

conversion and management, Vol. 41, pp. 389-399.

3. Babu A.K. and Devaradjane.G (2003), ‘Vegetable oil and their derivatives as fuels for CI engines – An overview’, SAE 2003-01-0767.
4. Bari S, Yu C W and Lim T H (2004), ‘ Effect of fuel injection timing with waste cooking oil as a fuel in a direct injection diesel engine’, D11103 c IMechE 2004.
5. Brent Bailey, James Eberhardt, Jimeii Erwin (1997), ‘Diethyl ether as a renewable diesel fuel’, SAE 972978.
6. Christopher A.Sharp, Steve A.Howell, Joe Jobe. (2001)**,** ‘The effect of biodiesel fuels on transient emissions from modern diesel engines, part II unregulated emissions and chemical characterisation.Christopher’.SAE 2001-01-1968.
7. Huang Z H, Lu H B, Jiang D M, Liu B, Zhang J Q and Wang X B (2004), ‘Engine performance and emissions of a compression ignition engine on the diesel-methanol blends’, D10903 c IMechE 2004.
8. Ikwuagwu.O.E, Ononogbu.I.C, Njoku.O.U (2000), ‘Production of biodiesel using rubber seed oil’. Industrial crops and product 12 (2000) 57-62.
9. John.B.Heywood, ‘Internal combustion engine fundamentals’, McGraw Hill Book Company, 1989.
10. LucioPostrioti, Michele Battisoni and Carlo N.Grimaldi, Federico Millo, (2003) ‘Injection strategies tuning for the use of bio-derived fuels in a common rail HSDI engine’, SAE 2003-01-0768.
11. Nagarajan.G, Rao.A.N, Renganarayanan.S (2002), ‘Emission and performance characteristics of neat ethanol fueled DI diesel engine’. International Journal of ambient energy, Vol.23, Number 3.