Performance Analysis of Diesel Engine using Biodiesel for Variable Compressible Ratio

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Abstract- **With high technological advantage and modernization, use of petroleum based fuel is increasing. But pertroeum based fuels are depleting in nature. They are not renewable as a result, demand is more than supply. Fuel costgoes on increasing day by day. Besides availability of cost, environmental issues are very important; pollution caused by this fuel is destroying life of ecosystem. Thus there is a need to search alternative fuel to petroleum based oil.**

In India,Jatropha, Soyabean and west cooking oil is used as a significant fuel source. These vegetable &non-vegetablebased oils have drawn the attention of researchers in recent time, as a high potential substrate for production of biodiesel. The petroleum products play on important role in our modern life. The costs of these products depend on international markets and petroleum reserves are limited to nearly 30 years. India is projected to become the third largest consumer of transportation fuel in 2020, after the USA and China, with consumption growing at an annual rate of 6. 8% from 1999 to 2020.

Vegetable based fuel have great potential as they are enviro-friendly. This paper focus on the use of Jatropha,Soyabean and west cooking oilas alternative fuel and their comparative performance result shows that this vegetable based fuel has better performance and emission characteristic to compared diesel..

Key Words - Jatropha, Soyabean and West Cooking Oil, Fuel Properties, Blends, Diesel Engine Test Rig, Performance, Emissions

I. INTRODUCTION

In 2005, India consumed 30 million tons of oil in the transport sector, of which 29% was gasoline and 71% was diesel. The Indian energy demand is expected to grow at an annual rate of 4. 8% over the next couple of decades. It has been projected that India will double its oil consumption, at least, by 2030, when India will become the third largest oil consumer in the world. Bio-fuel production could, therefore, potentially play a major role in this respect.

The trials with such blends are on-going in various states of India. The government of India has set a target to increase the blend of biofuels and diesel to 20% by 2017.

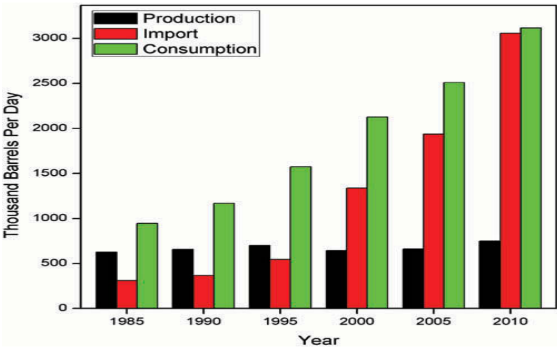

Fig. No. -1. 1 Production, importation, and consumption of crude oil in India.

Jatropha curcas has drawn the attention of researchers in recent times as a high potential substrate for production of biodiesel. However, like many other substrates, fuel properties of its biodiesel vary with such factors as growing and climatic conditions. Since the last few decades, researchers world over have been trying to find new alternative fuels that are available, technically feasible, economically viable and environmentally acceptable. Biodiesel as an alternative fuel is one of the best alternatives among other sources due to its high potential to reduce levels of emissions such as HC, CO and smoke when used in engines, in addition to being renewable and biodegradable.

1. 2 Motivation-

PCRA (Petroleum Conservation and Research Association) has reported that the world's available fossil fuel reserves may deplete in coming 50-79 years. Such reserves are concentrated in certain regions that are vulnerable to political, economic, social and military instability which could potentially pose serious problems in future.

In world, 1^{st} largest in democracy,7^{th} largest by areaand number 2 position in population we are having and at the same depend on gulf country for mineral fuel. Such Gulf countries are violent may not be supply fuel in future so we should prepare for the alternative. Second thing the acid rain, global warming and health hazards are the results of ill effects of increased polluted gases like SOx, CO and particulate matter in atmosphere.

Rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum fuels for engines.

1. 3 Objective-

The objective of this work is

[1] To investigate performance characteristic such as thermal efficiency, and brake specific fuel consumption of biodiesel from Jatropha,Soyabean and Karanja Oil blends 0n variable compression ratio.
[2] To compare performance characteristic of biodiesel fuel to diesel.
[3] To estimate Emission of HC, NOx, CO, and smoke of the exhaust gas measured.

1. 4 Literature Review-

[1] Shashi Kumar Jain, Technical Sustainability of Jatropha Biodiesel and its blends with diesel, Properties of jatripha biodiesel have been compared with properties of petro-diesel; showing a comparable regime for satisfactory performance of CI engine with biodiesel.
[2] Y. V. Hanumantha Rao, Andhra Pradesh. The fuel properties of Jatropha biodiesel such as kinematic viscosity, calorific value, flash point, carbon residue and specific gravity were found. Results indicated that B25 has closer performance to diesel and B100 has lower brake thermal efficiency, mainly due to its high viscosity compared to diesel.
[3] BelachewTesfa et al (2014), in their paper, the effects of biodiesel types and biodiesel fraction on the emission characteristics of a CI engine were study. The results also clearly indicate that the engine running with biodiesel and blends have higher NOx emission by up to 20%.
[4] An*et al.* (2013) study on the performance and combustion characteristics of biodiesel and its blend fuels shows that biodiesel/blend fuels have high break specific fuel consumption of about 42% at 25% engine load and low engine speed. There was an increase in brake thermal efficiency of biodiesel compared to pure diesel at 50% and 100% load.
[5] MayankChabra, Noida-Soyabean oil with blends B15,B25,B35 and B45 and effects on brake power, specific fuel consumption,brake thermal efficiency studied and the test report at B15 blends of bio diesel can act as alternative fuel.
[6] F. K. Forson, Department of Mechanical Engineering-An experimental investigation was conducted to explore the performance of jatropha oil and its fuel blends with diesel in a direct-injection single-cylinder diesel engine and the results obtained -Pure jatropha, pure diesel and blends of jatropha and diesel oil exhibited similar performance and broadly similar emission levels under comparable operating conditions..The jatropha oil has substantial prospects as a long-term substitute for diesel fuels. The 97. 4%diesel/2. 6% jatropha fuel blend competed favourably with diesel fuel and offers a reasonable, if not even a better, substitute for pure diesel fuel.
[7] As per Jehad (2012), the use of waste, oil biodiesel has showed an increase of 4. 75% in fuel density compared to pure diesel and also there was a 13. 43% decrease in calorific value of fuel and 7. 24% for unused oil biodiesel. The biodiesel showed improvement in the power, thermal efficiency, torque and reduction in the specific fuel consumption
[8] JiantongSong,JiangLv,China,-Experimental study on a Diesel engine fuelled wit soyabeanbiodiesel,with increase the biodiesel in blends brake power,torque and brake specific efficiency increases,except B10 smoke efficiency decreases and NOx emission increases.
[9] Vivek and A AK Gupta- Biodiesel Production from Karanja Oil- Pressure 1 atmospheric,temperature 68-80 degree Celsius, Reactant ratio 8-10 of (MeOH:oil) Reaction time 30-40min,Catalyst (KOH) 1. 5 per cent.
[10] A G MataniMukeshMane,Amravati India- karanja Blends 10%20,30,40,and 100%diesel compared at different injection perssur 150bar,170bar and 210bar. as pressure increase the brake thermal efficiency also increases and brake specific fuel consumption is lowered as the injection pressure is increases.
[11] Journal of the Taiwan Institute of Chemical Engineers 44 (2013) 214–220

Jatropha oil methyl esters (JMEs) produced from jatropha (Jatropha curcas) oil were blended with diesel at various volumetric percentages to evaluate the variations in the fuel properties. Correlations between fuel properties, including the calorific heat, cold filter plugging point, density, kinematic viscosity, and oxidation stability of the JMEs–diesel blends, and the blending ratio of the JMEs have been established. As a result, a blending ratio of the JMEs with diesel was recommended up to 40 vol. % in comparison with the relevant specifications for biodiesel–diesel blends. The combustion tests of the JMEs–diesel blends were performed in a diesel generator. Higher brake thermal efficiency and lower brake specific fuel consumption were clearly observed with higher output loading. The concentration of carbon dioxide and nitrogen monoxide in the exhaust gas increased with higher output loading while the concentration of oxygen and carbon monoxide decreased..

II. EXPERIMENTAL SET UP-

The variable compression ratio (VCR) diesel engine used to conduct the experiments is a single cylinder, four strokes, water cooled, direct injection engine. The technical specifications of the engine are given in Table 2. 1. The engine is mounted on a stationary frame with a suitable cooling system. The lubricating system is inbuilt in the engine.

The emission measurement system is used to measure the constituents of exhaust gas and its system consists of an exhaust gas analyzer. The exhaust gas analyzer measures the exhaust gas constituents of Carbon dioxide (CO_2), Carbon monoxide (CO), Oxides of nitrogen (NOx), Unburnt Hydrocarbons (HC), and Oxygen (O_2). A photographic image of the assembly of the emission measurement systems used in the experiment is given in Figure 2. 2.

Fig No-2. 1 Experimental setup of VCR Engine

Figure 2. 2-Exhaust Gas Analyzer

Table 2. 1 Engine Specifications

Manufacturer	M/s Kirloskar Oil Engines Ltd.
Model	TV 1
Cycle	4 STROKES
Rated Power	3. 5 kW @ 1500 RPM
Type of Combustion System	Direct Injection
No. of Cylinders	1 Cylinder
Bore/Stroke	87. 5 /110 mm
Compression Ratio	17. 5 : 1 Modified to VCR12 to18 : 1
Swept Volume	0. 661 cc
Type of Cooling	WATER COOLED
Fuel Injection	INLINE

III. PERFORMANCE PARAMETER:

3. 1 Brake Specific Fuel Consumption

The brake specific fuel consumption is defined as the fuel flow rate per unit power output. It is a measure of the efficiency of the engine in using the fuel supplied to produce work. It is desirable to obtain a lower value of BSFC meaning that the engine used less fuel to produce the same amount of work. This is one of the most important parameters to compare when testing various fuels.

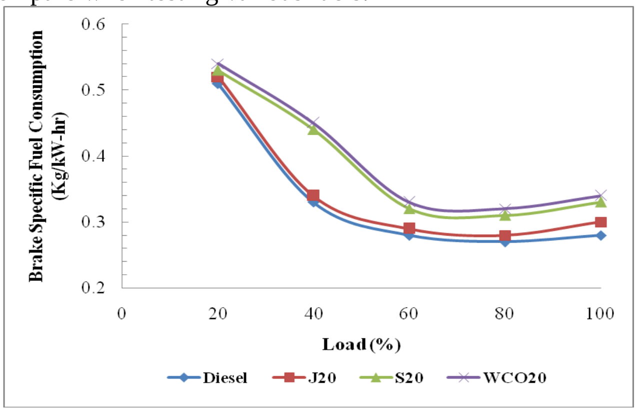

Figure 3. 1 (a) Variation of Brake Specific Fuel Consumption with Engine Load for B20 at Constant Speed 1500rpm at CR 16

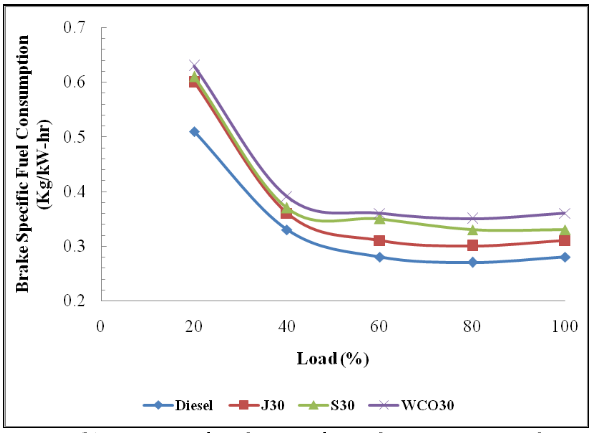

Figure 3. 1 (b) Variation of Brake Specific Fuel Consumption with Engine Load for B30 at Constant Speed 1500rpm at CR 16

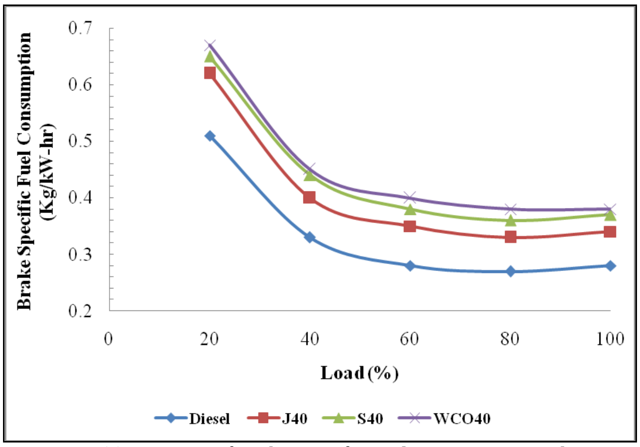

Figure 3. 1 (c) Variation of Brake Specific Fuel Consumption with Engine Load for B40 at Constant Speed 1500rpm at CR 16

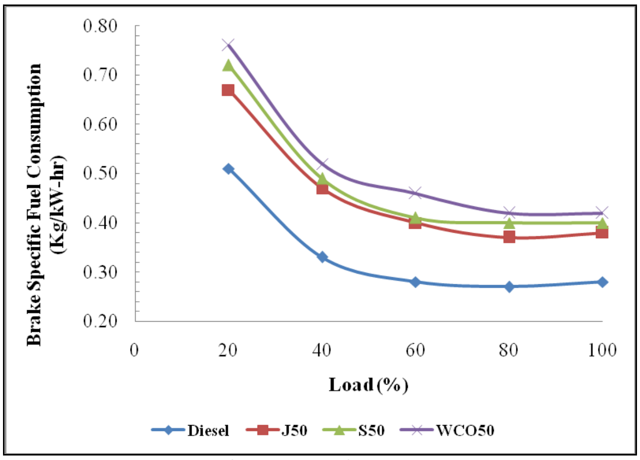

Figure 3. 1 (d) Variation of Brake Specific Fuel Consumption with Engine Load for B50 at Constant Speed 1500rpm at CR 16

Amongst the all the blends Jatropha blend have shown least BSFC for the all the loads and the blends followed by the soybean and waste cooking oil blends. B-20 of jatropha biodiesel has shown 0. 28 kg/kW-hr for 80% load which very close to diesel fuel (0. 27 kg/kW-hr for 80% load) followed by soybean 0. 31 kg/kW-hr for 80% load and waste cooking oil 0. 32 kg/kW-hr for 80% load. The possible reason for the above behavior may be the jatropha biodiesel has higher calorific value as compared to other blends and also it is less viscous.

The performance of the pure diesel is superior than all the blends at all load conditions, the reason for that may be as compared to diesel the biodiesel has lower calorific value and higher viscosity. Hence leads to higher fuel consumption for the same power.

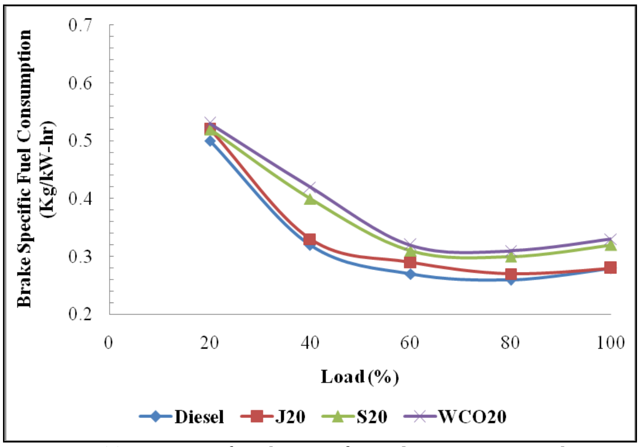

Figure 3. 2 (a) Variation of Brake Specific Fuel Consumption with Engine Load for B20 at Constant Speed 1500rpm at CR 17

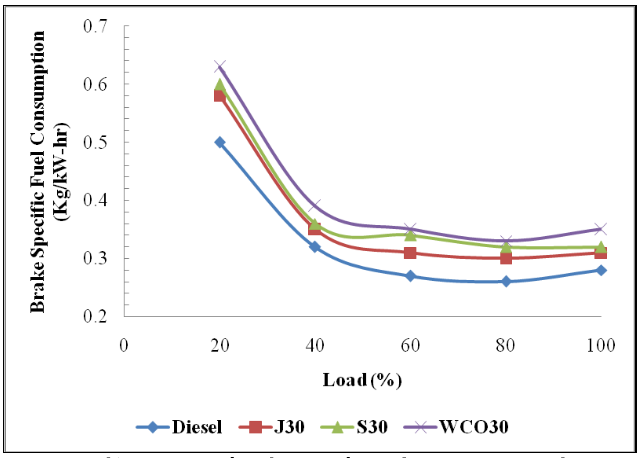

Figure 3. 2 (b) Variation of Brake Specific Fuel Consumption with Engine Load for B30 at Constant Speed 1500rpm at CR 17

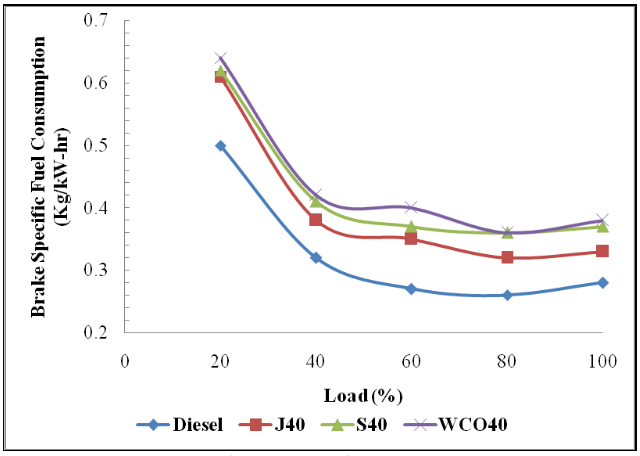

Figure 3. 2 (c) Variation of Brake Specific Fuel Consumption with Engine Load for B40 at Constant Speed 1500rpm at CR 17

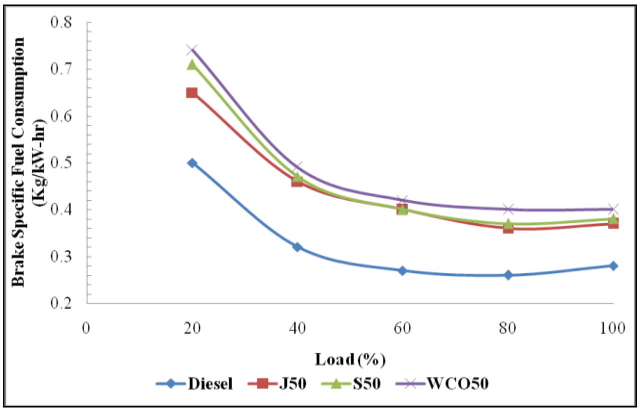

Figure 3. 2 (d) Variation of Brake Specific Fuel Consumption with Engine Load for B50 at Constant Speed 1500rpm at CR 17

3. 2-BRAKE THERMAL EFFICIENCY-

Thermal efficiency is the ratio between the power output and the energy input through fuel, the latter being the product of the injected fuel mass flow rate and the lower heating value. Thus, the inverse of thermal efficiency is often referred to as brake specific energy consumption. Since it is usual to use the brake power for determining thermal efficiency in experimental engine studies, the efficiency obtained is really a brake-specific efficiency. The brake thermal efficiency of biodiesel blends and diesel at various loads and compression ratio is shown in the figures. It is observed from the figures that the brake thermal efficiency of biodiesel blends is slightly lower than that of standard diesel at all load.

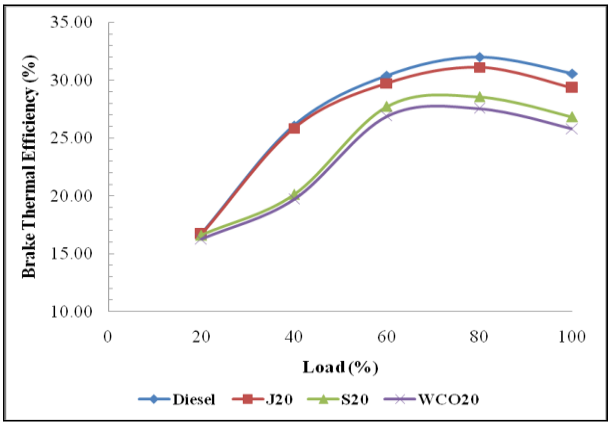

Figure 3. 4 (a) Variation of Brake Thermal Efficiency with Engine Loadfor B20 at Constant Speed 1500rpm at CR 16

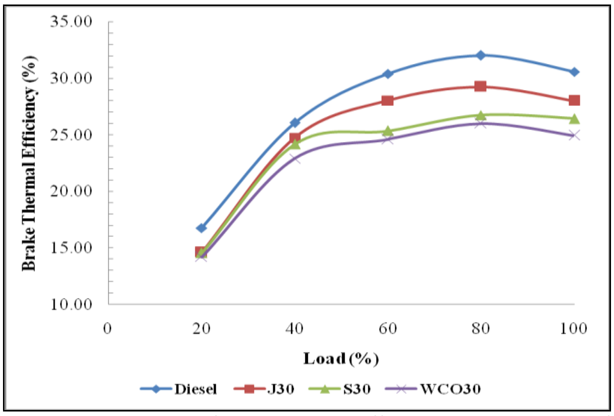

Figure 3. 4 (b) Variation of Brake Thermal Efficiencywith Engine Load for B30 at Constant Speed 1500rpmat CR 16

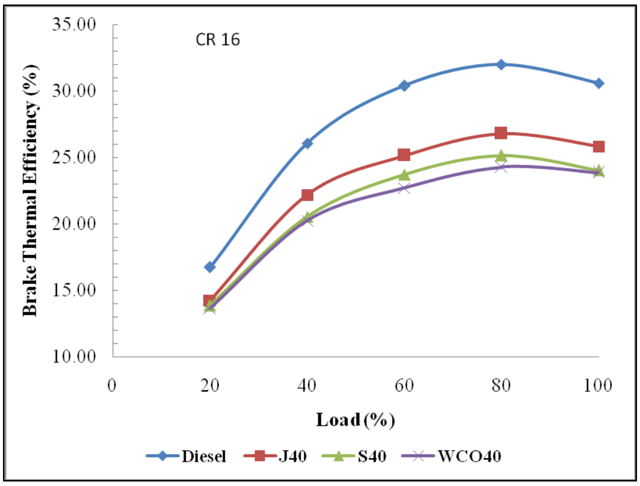

Figure 3. 4 (c) Variation of Brake Thermal Efficiency with Engine Load for B30 at Constant Speed 1500rpmat CR 16

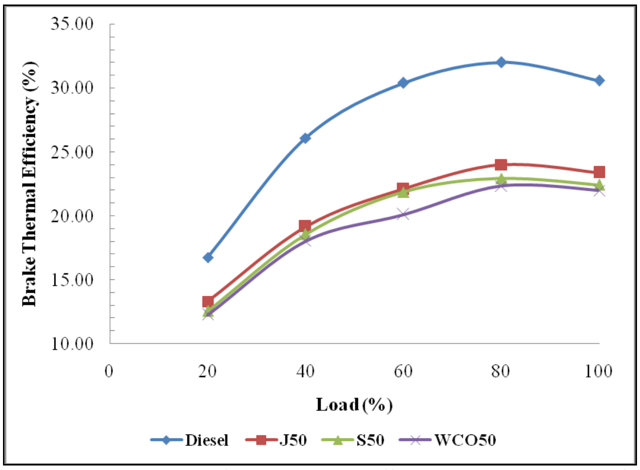

Figure 3. 4 (d) Variation of Brake Thermal Efficiency with Engine Load for B50 at Constant Speed 1500rpm at CR 16

It is also observed from the figures that as the blend ratio increases the brake thermal efficiency decreases. The maximum brake thermal efficiency is obtained for jatropha B-20 is 31. 99 % at 80 % load and least for the waste cooking oil B-50 is 23. 73 % at 80% load.

This decrease in brake thermal efficiency with increase in blend ratio is due to lower heating value of biodiesel and higher viscosity

IV. EXHAUST GAS TEMPERATURE (ExGT)

Variations in exhaust gas temperature with load for various blends are shown in below Figures. It is noticed that exhaust gas temperature increases with increase in engine load and compression ratio.

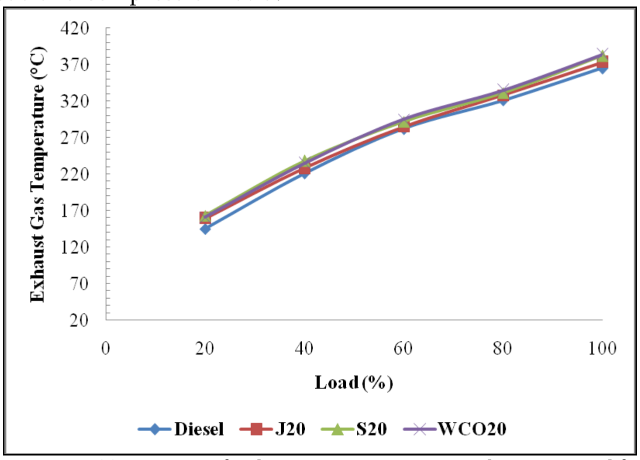

Figure 4. 1 (a) Variation of Exhaust Gas Temperature with Engine Load for B20 at Constant Speed 1500rpm at CR 16

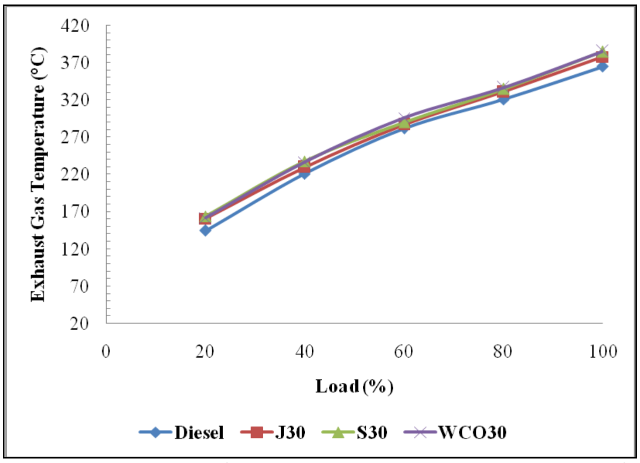

Figure 4. 1 (b) Variation of Exhaust Gas Temperature with Engine Load for B30 at Constant Speed 1500rpm at CR 16

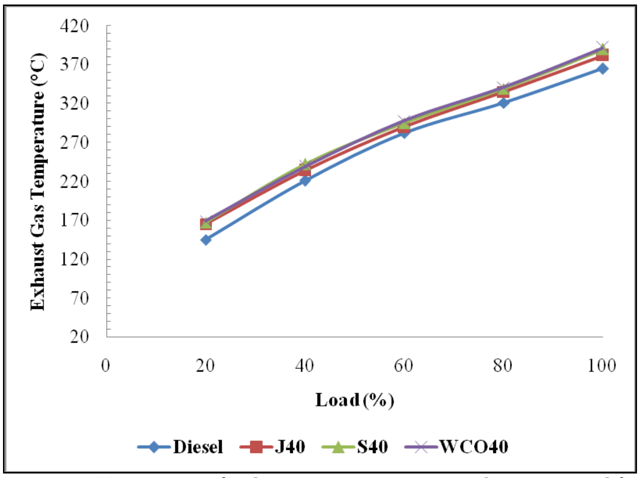

Figure 4. 1(c) Variation of Exhaust Gas Temperature with Engine Load for B40 at Constant Speed 1500rpm at CR 16

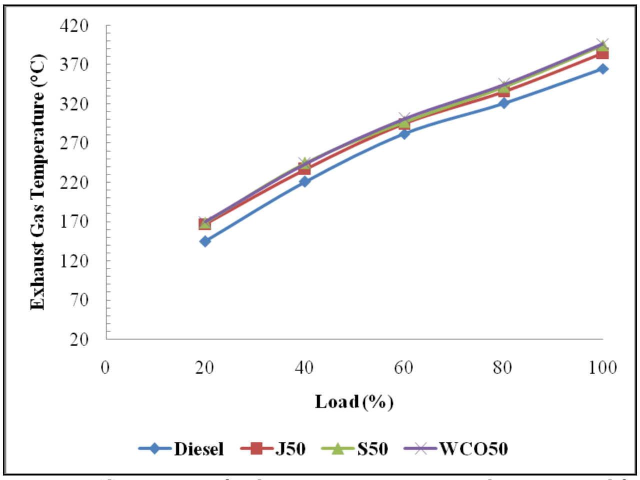

Figure 4. 1 (d) Variation of Exhaust Gas Temperature with Engine Load for B50 at Constant Speed 1500rpm at CR 16

The variation of exhaust gas temperature with the engine load for various blends (B-20, B-30, B-40 and B-50) of jatropha biodiesel, soybean biodiesel and waste cooking oil biodiesel are shown in figure 4. 9 (a) - 4. 9 (d) for the constant speed of 1500rpm and compression ratio 16.

Figure shows that as the load increases the exhaust gas temperature increases for the biodiesel blends. The diesel fuel shows less exhaust gas temperature as compared to all the biodiesel blends at all loads. The exhaust gas temperature for the B-20 blends of jatropha, soybean and waste cooking oil are 373 °C, 382º C and 384 °C respectively. The jatropha biodiesel blends has shown average exhaust gas temperature 0. 14 % higher than diesel. The soybean biodiesel blends has shown average exhaust gas temperature 0. 23 % higher than diesel. The waste cooking oil biodiesel blends has shown average exhaust gas temperature 0. 24 % higher than diesel.

The possible reason for higher exhaust gas temperature may be late burning of biodiesel in the cylinder due to more oxygen content in the biodiesel blends and complete combustion of biodiesel.

4. 2-ENGINE EMMISION TEST

CO emissions are a result of the lack of oxygen and low combustion temperature, resulting in incomplete oxidation of CO to CO_2. Hemoglobin present in the blood has a greater affinity for CO than for O_2 and thus inhaling CO leads to a lack of oxygen in the blood, resulting in headaches, unconsciousness, coma or even death, depending upon the duration and concentration of CO. Hence study of CO emissions is very important

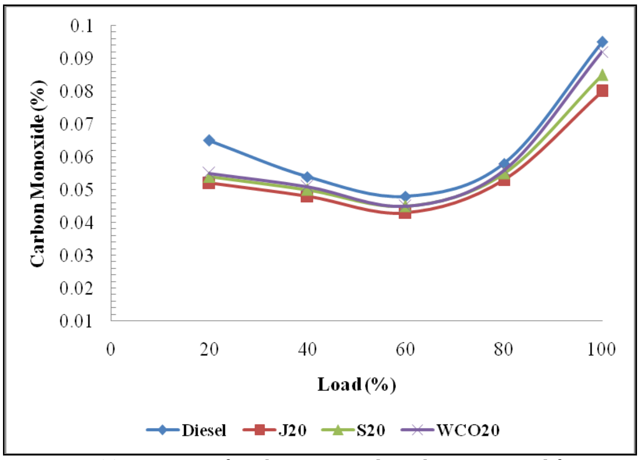

Figure 4. 2 (a) Variation of Carbon Monoxide with Engine Load for B20 at Constant Speed 1500rpm at CR 16

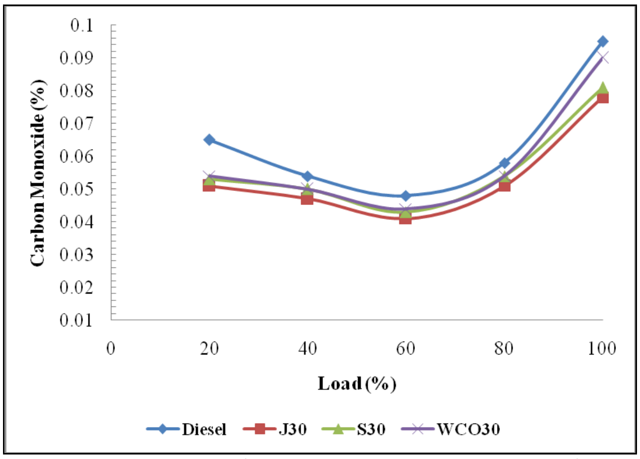

Figure 4. 2 (b) Variation of Carbon Monoxide with Engine Load for B30 at Constant Speed 1500rpm at CR 16

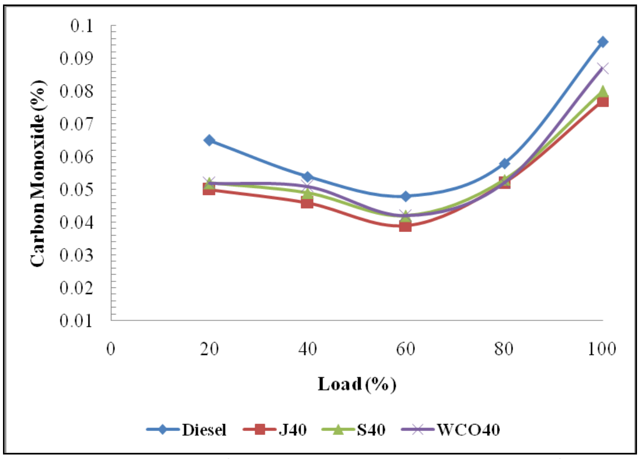

Figure 4. 2 (c) Variation of Carbon Monoxide with Engine Load for B40 at Constant Speed 1500rpm at CR 16

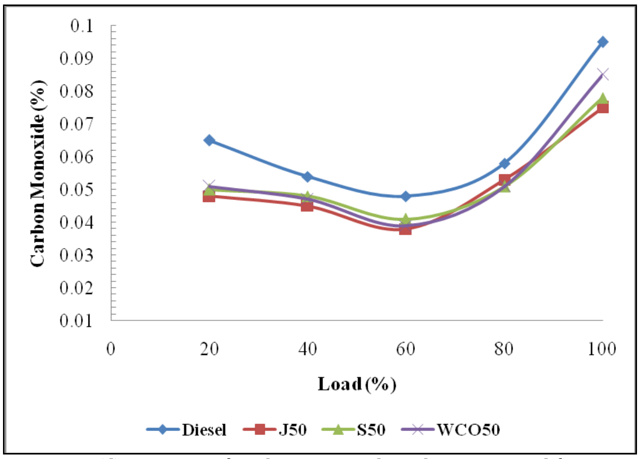

Figure 4. 2 (d) Variation of Carbon Monoxide with Engine Load for B50 at Constant Speed 1500rpm at CR16

It can be seen from the above figures that CO emissions decrease with increase in the percentage of biodiesel in the fuel blends with diesel fuel. The mean values of CO emissions with B-20 are 0. 0552, 0. 0578, and 0. 0598 for jatropha J-20, Soybean S-20, WCO-20 respectively and for B-50 these values are 0. 0518, 0. 0536, and 0. 0546 for jatropha J-50, Soybean S-50, WCO-50 respectively which are lower as compared that of diesel fuel value of CO emission 0. 065. This is because at elevated temperature, the performance of engine improved with relatively better burning of the fuel which results in decreased CO emission for biodiesel blends. However further loading, the excess fuel required led to the formation of more smoke, which might have prevented the oxidation of CO into CO_2, consequently increasing the CO emissions sharply.

VI. CONCLUSION:

Biodiesel is a viable substitute for petroleum-based diesel fuel. Its advantages are improved lubricity, higher cetane number, cleaner emissions (except for NOx), reduced global warming, and enhanced rural development. Vegetable based oil has potential as an alternative energy source. The use of vegetable biodiesel reduces environmental impact of transportation, the dependency on crude oil import and may offer business possibilities to agriculture sector for the excesses production.

Use of vegetable based biodiesel and its blends will give better engine performance and emission, when fuelled single cylinder compression ignition engine.

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[5] Vol. 8, no. 11, november 2013, issn 1819-6608. arpnJournal of Engineering and Applied Sciences ©2006-2013 Asian Research Publishing Network (ARPN). All rights reserved. **fuel properties of jatropha methyl ester and its blends with petroleum diese**LJerekias Gandure1, Clever Ketlogetswe1 and Abraham Temu2 1Department of Mechanical Engineering, University of Botswana, Gaborone, Botswana 2Department of Chemical and Mining Engineering, University of, Dar es Salaam, Tanzania

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