International Journal of Engineering Research
Volume No.3 Issue No: Special 1, pp: 52-57
ISSN:2319-6890)(online),2347-5013(print)
22nd March 2014

Performance Tests and Study of Combustion Characteristics Of Rice Bran Oil As a C.I Engine Fuel

V. Nageswara Reddy[1], R. Madhu Kumar[2], R.Vidya Sagar Raju[3]

[1,2,3] School of Mechanical Engineering, RGMCET, Nandyal.

Corresponding Email: vnreddy70@gmail.com

Abstract— **At present, about 80% of the world's demand for transportation fuels- road, rail, air and sea- are met by derivatives from the fossil fuels such as petroleum and diesel. This project aims at finding an alternative for these fossil fuels. The various parameters that have been considered for the selection of the oil are kinematic viscosity, viscosity index, calorific value, flash point, fire point, sulphur content, carbon content, pour point, and density etc. The various properties of the oil was tested at M/s Industrial testing and analysis laboratories, Chennai. The oil was then converted to biodiesel using trans-esterification process. This trans-esterification process was carried out at the Central Leather Research Institute, Chennai. The first step consisted of testing and analysis of the performance and combustion characteristics of diesel, the rice bran oil, ethyl ester of rice bran oil and various blends of both these oils with diesel. This step also consisted of measuring and observing the emission characteristics with the help of a Bosch smoke meter. The final step consisted of evaluating and comparing the performance, combustion, and emission characteristics of the fuels with one another with the help of graphs.**

Keywords— **Helical coil tube heat exchangers, Parallel flow, Counter flow, Flow rate of cold water, and Number of turns in helical coil.**

I. Introduction

The world petroleum situation due to rapid depletion of fossil fuels and the degradation of the environment due to the combustion of fossil fuels have caused a resurgence of interest in finding alternative fuel. Internal combustion engines form an indispensable part to the transportation as well as mechanized agricultural systems. Thermodynamic tests, based on engine performance evaluation have established the feasibility of using a variety of alternative fuels such as hydrogen, CNG, alcohols, biogas, producer gas and a host of vegetable oils. In Indian context, biodiesel developed from non edibleoil seeds and edible oil seeds can be used in diesel engines. Vegetable oil based fuels are biodegradable, non-toxic and significantly reduce pollution. Reports on the use of biodiesel in diesel engines indicate a substantial reduction in SO_2, CO, smoke, noise and particulate emissions. Biodiesel in abroad have been developed from saffola, sunflower, peanut, rape seed, linseeds etc. On the other hand, there is a vast resource of wild/non-edible seeds, which can be grown in the wasteland of the country to produce biodiesel. The viscosity of vegetable oil being 10-20 times more and viscosity index being low, the spray characteristics of these oils are different, which lead to a different heat release pattern and emission characteristics. High viscosity can cause poor atomization large droplets and high spray jet penetration. This results in poor combustion, accompanied by loss. Vegetable oils have larger molecules, up to four times larger than diesel fuel molecules. The high molecular weights of vegetable oils result in low volatility as compared to diesel fuel, which leads to the oils sticking to the injector or cylinder walls. Tests have shown that by way of transesterification it is possible to over come all of the problems associated with vegetable oil fuels.

Yasufumi Yoshimoto *et al* (2001) carried out an investigation on the reduction of NO_x and smoke emissions in a diesel engine fueled by biodiesel emulsion (ethyl ester of fried oil and gas oil) combined with Exhaust gas reduction. Masataka Hashimoto *et al* (2001) conducted experiments to evaluate the combustion characteristics of rape seed oil in a diesel engine. He used a 4 cycle pre-combustion chamber diesel engine was as the test engine. NO_x, CO_2, CO, O_2 and Smoke emissions in the exhaust gas were measured with change in the engine load.curcas oil and diesel fuel blends in compression ignition engine. He tried to reduce the viscosity of jatrophacurcas oil close to that of conventional fuel so as to make it suitable for use in a C.I. engine and to evaluate the performance of the engine with the modified oils. S. Bari *et al* (2001) conducted experiments to find out the effects of preheating of crude palm oil on injection system, performance and emission of a diesel engine. They found out that the viscosity of CPO at room temperature is too high to allow smooth flow in fuel lines. To lower its viscosity, CPO needs to be heated. The modified friction test performed to investigate the influence of heating showed that heating of fuel up to 100°C had no adverse effects on the fuel injection system.

A.M.Nagaraja*et al* (2004) carried out the investigation of characterization and optimization of rice bran oil for CI engines at different injection pressures. They found out that the diesel engine performed satisfactorily on biodiesel fuel without any engine hardware modifications. The 20 percent biodiesel blend

International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 1, pp: 52-57 22nd March 2014

was found to be the optimum concentration for biodiesel blend which in turn improved the thermal efficiency of the engine by 2.5 percent and reduced the brake specific energy consumption. NO_x emissions in the case of biodiesel fuel are higher by approximately 4 %. These higher NO_x emissions may be due to higher temperature of the combustion chamber.

M.Mathiyazhagan [5]researched on the non-edible oils as feed stocks for biodieselproduction to reduce the cost of biodiesel. Normally alkali catalyzed method was followed for biodiesel production process. However the non-edible oils having high FFA content which is not suitable for normal transesterification process. Hence a two-step catalyzed method was used to prepare the biodiesel. High FFA content of non-edible oils were efficiently converted into biodiesel fuel.P.K.Gupta [6] discussed the effect of various parameters on yield and conversion of oil tobio-diesel prepared from rice-bran oil. Percent conversion as well as yield was good at molar ratio of 6:1, reaction time of 4 hour and oil temperature of 60ºC. Yield showed an increasing trend with increase in oil temperature or reaction temperature. Increase in FFA content resulted in decreased yield but conversion remained unaffected.NovySrihartatiKasim[7]carried out the study of reaction between supercriticalmethanol and rice bran or DDRBO(dewaxed degummed rice bran oil) with CO2 as the co-solvent. The production of FAMEs(fatty acid methyl esters) by in situ transesterification of rice bran and supercritical methanol was not a promising way. It was found that the yield of biodiesel was low (51.28%) and rice bran cannot be recovered for reuse.Yi-Hsu Ju, ShaikRamjanVali[8]discussed that the main concern with biodiesel fuel is itshigh price. One of the future aims in biodiesel research is on the selection of inexpensive feedstock with high value-added byproducts. Young-CheolBak [9]investigated the transesterification of rice bran oil to produce thebio-diesel oil. Experimental condition included molar ratio of rice bran oil to alcohol(1:3, 1:5, 1:7), concentration of catalyst used(0.5,1.0 and 1.5 wt%), types of catalysts(sodium methaoxide, NaOH and KOH), reaction temperatures(30,45 and 60°C) and types of alcohols(methanol, ethanol and butanol).G. VenkataSubbaiah [10]investigated the performance and emission characteristics ofconventional diesel, rice bran oil biodiesel, diesel and biodiesel blend and diesel-biodiesel-ethanol blends on a single cylinder diesel engine. The conclusions of the investigation were , the maximum brake thermal efficiency of 28.2% was observed with the blend B10E15.The BSFC of the biodiesel and all the other fuel blends was higher than that of the diesel fuel.The exhaust gas temperature of the blend B10E15 was slightly lower than that of diesel fuel throughout the range of the load on the engine. The CO emissions of the biodiesel and all the other fuel blends were lower than that of the diesel fuel. The minimum CO emissions were observed with the blend B10E15 well below the diesel fuel and the biodiesel.The HC emissions increased with the increase of ethanol percentage in diesel-biodiesel-ethanol blends, but lower than those of the diesel at higher loads on the engine.TheNOx emissions of the biodiesel and all the other fuel blends were low at lower loads and high at higher loads compared with the diesel fuel .The CO2 emissions of the biodiesel and all the other fuel blends were higher than that of the diesel fuel.

II. EXPERIMENTAL METHODOLOGY

Here a brief description of the apparatus and its method of operation is given. Along with it different performance and exhaust emission parameters are also discussed. Fig.1 shows the schematic diagram of the complete experimental setup.

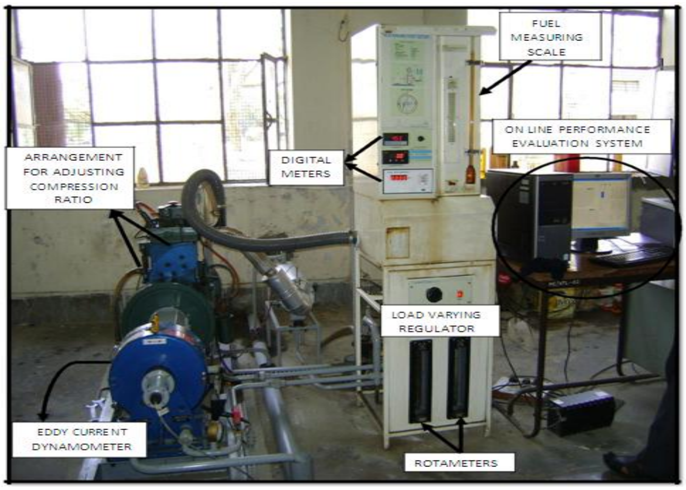

Figure 1. Pictorial view of the compression ignition engine.

The specifications of the diesel engine are given in table 1.

Make	Kirloskar model AV1
Cooling method	Water cooled
Starting condition	Cold start
Ignition technique	Compression ignition
Bore (D)	80mm
Stroke (L)	110 mm
Rated speed	1500 r
Rated power	5 hp (3.72 kW)

A tilting cylinder block arrangement is used for the compression ignition without stopping the engine. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for P -V diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rota meters are provided for cooling water and calorimeter water flow measurement.

Methods of improving the performance of straight vegetable oils

- Preheating the vegetable oil
- Addition with another light vegetable oil like for example orange peel oil
- Blending with fossil fuels like diesel
- Adding with an oxygenate like dimethyl carbonate or diethyl-ether
- Dual fuel operating with hydrogen or LPG
- Trans-esterification

III. PERFORMANCE TESTING AND EVALUATION

Selection of oil

A study was conducted on the various possible straight vegetable oils (SVO's) that could be effectively used as alternatives to diesel. The various parameters that were considered for the selection of the oil are density, viscosity, calorific value, flash point, fire point, pour point etc.

The various straight vegetable oils (SVO) that were considered for the study are:

- Sunflower oil
- Jatropha oil
- Cotton seed oil
- Mahua oil
- Rice bran oil

The testing was done on the oil to obtain values of primary fuel parameters such as

Calorific Value

Flash Point

Density

Kinematic Viscosity

The properties of some fuels are listed below in the table.

Properties		RiceBran Oil	Cotton seed oil	Jatropha Oil
Calorific Valve(kj/kg)	42490	40164	21609	39774
Density(kg/m^3)	840	909	915	918
Kinamatic Viscosity	4,59	30	33	48
Flash Point(0C)	75	126	215	240

PERFORMANCE TESTING

Experiments were conducted for examining the engine performance initially with diesel, pure rice bran oil, and then blends of both these two fuels in the following ratios

% of rice bran oil	% of diesel
20	80
40	60
60	40
80	20

Similarly tests were carried out using ethyl esters of rice bran oil which was obtained as a result of the transesterification of the pure rice bran oil. The various parameters calculated are as follows.

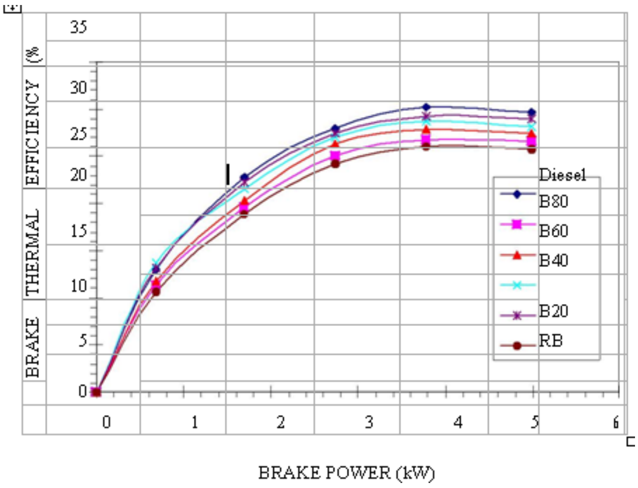

FIGURE 1. VARIATION OF BRAKE THERMAL EFFICIENCY vs. Brake power

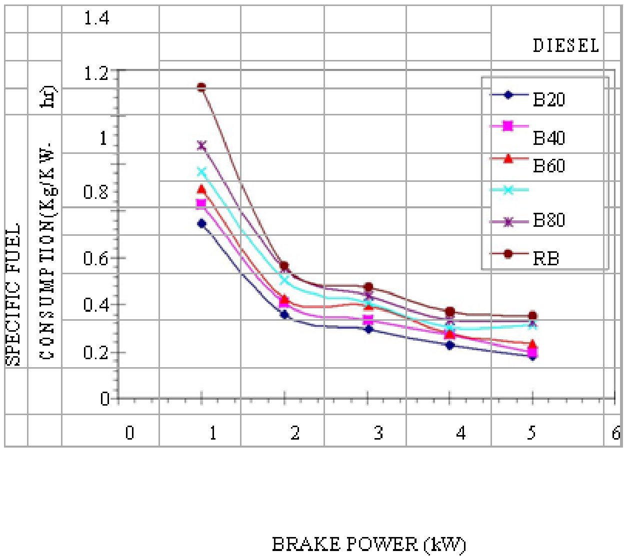

FIGURE 2. VARIATION OF SFC vs. Brake power

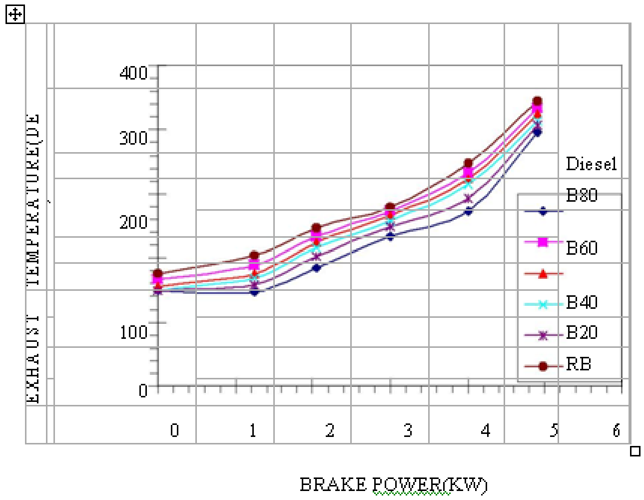

FIGURE 3. VARIATION OF Exhaust temp. vs. Brake power

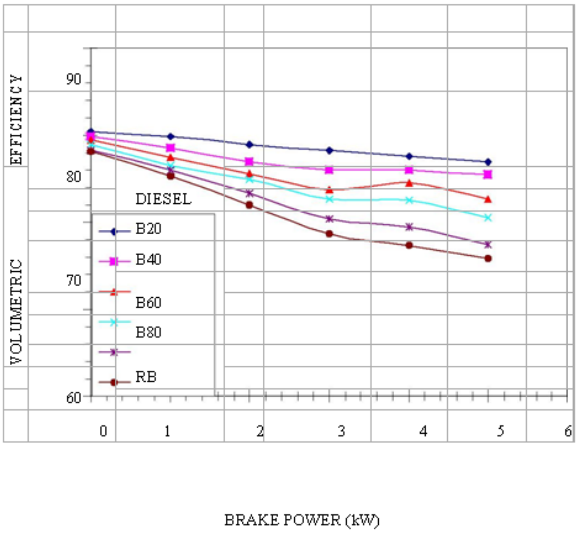

FIGURE 4. VARIATION OF Volumetric Effi. vs. Brake power

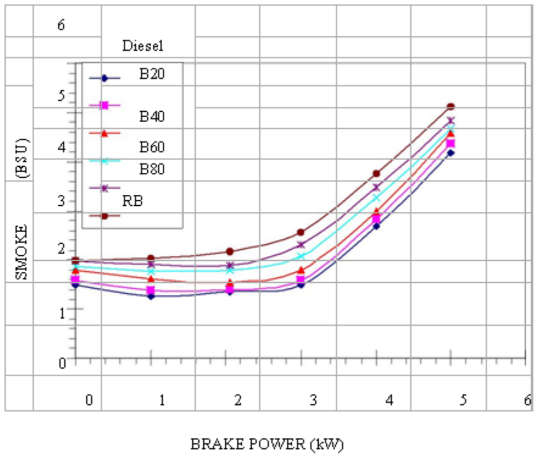

FIGURE 5. VARIATION OF Smoke vs. Brake power

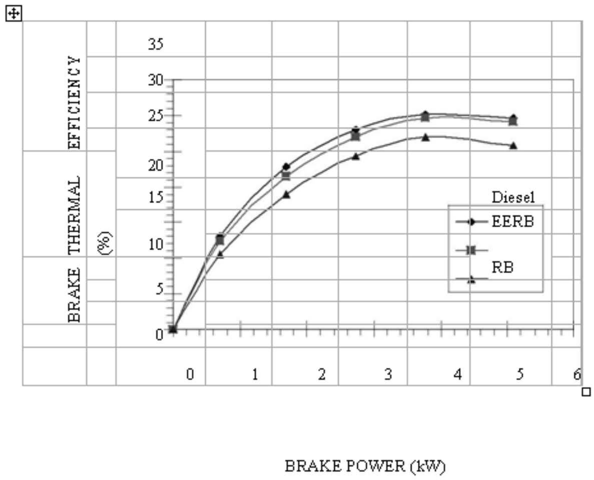

FIGURE 6. VARIATION OF BTE vs. Brake power

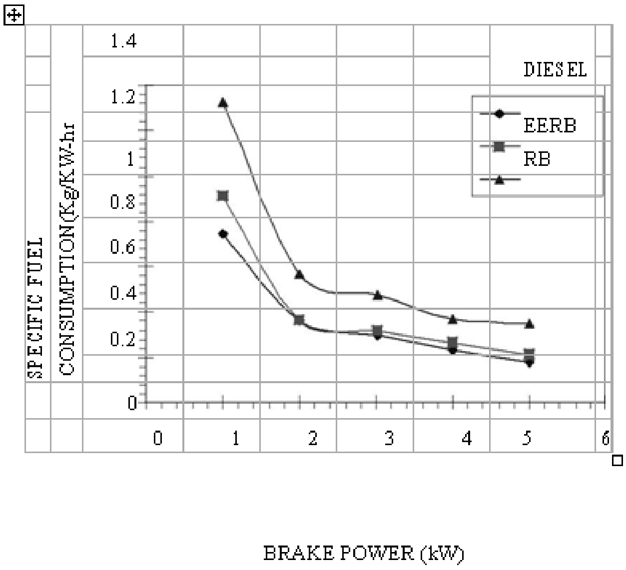

FIGURE 7. VARIATION OF SFC vs. Brake power

IV. Results And Discussion

In this section the performance, emission and combustion characteristics of the engine under various load conditions have been compared for rice bran oil, ethyl ester of rice bran oil, and diesel.

Evaluation of performance, combustion and smoke characteristics of rice bran oil

Brake thermal efficiency

The brake thermal efficiency variations with power output for the rice bran oil and diesel are shown in figure 1. Due to poor mixture formation because of higher viscosity, higher density and low volatility, the thermal efficiency of ricebran oil is always lower than that of diesel. The maximum efficiency of the engine was 25.8 % for rice bran oil at the peak power output and it was 29.7 % for diesel.

Specific fuel consumption

The variation of specific fuel consumption of the rice bran oil with diesel is shown in figure 2. The specific fuel consumption oil is lower than rice bran oil at all loads. This is because of lower calorific value, high viscosity and poor volatility of the fuel. As the volatility is poor, the quantity of fuel utilized for an equal power as compared to that of diesel is more which results in more specific fuel consumption.

Exhaust gas temperature

The exhaust gas temperature variation for rice bran oil and diesel are shown in figure 3. The maximum temperature of the exhaust gas was 446^0 C for rice bran oil and 397^0 C for diesel. The increase in the exhaust gas temperature is due to the poor volatility and high viscosity of the fuel which has lead to poor combustion. The variation of brake thermal efficiency ,specific fuel consumption ,exhaust temperature, volumetric efficiency, peak pressure, smoke level for the various blends are compared with diesel and rice bran oil for various power outputs in the figures1, 2, 3, 4, 5, The variation of brake thermal efficiency ,specific fuel consumption ,exhaust temperature, volumetric efficiency, peak pressure, smoke level for the various blends are compared with diesel and rice bran oil for various power outputs in the figures 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5,2.4.6 respectively. From the graphs it is inferred that as the percentage of diesel increases in the blend the performance also improves. This may be because of diesel which as an additive improves the volatility and reduces the viscosity.From the graphs it is inferred that as the percentage of diesel increases in the blend the performance also improves. This may be because of diesel which as an additive improves the volatility and reduces the viscosity.

Evaluation of performance, combustion and smoke characteristics of ethyl ester of rice bran oil.

Brake thermal efficiency

The brake thermal efficiency variations with power output for the ethyl ester of rice bran oil and diesel are shown in figure 2.5.1. Due to high mixture formation because of reduced viscosity, reduced density and improved volatility (due to transesterification) ,the thermal efficiency variation with power output of the ethyl ester of rice bran oil is similar to that of diesel. This can be clearly inferred from the graph which also clearly shows that the thermal efficiency of the rice bran oil is improved upon transesterification.

Specific fuel consumption

The variation of specific fuel consumption for the ethyl ester of rice bran oil with diesel is shown in figure 5. The specific fuel consumption oil is reduced upon transesterifcation as clearly inferred from the graph. It also shows that when the engine is run on the ethyl ester, the engine consumes more or less the same amount of fuel that the engine usually consumes when it is run on diesel at all loads. This is mainly because of increased and higher calorific value, low viscosity and improved volatility of the fuel.

Exhaust gas temperature

The exhaust gas temperature variation for the ethyl ester of rice bran oil and diesel are shown in figure 6. It clearly shows that there is not much of a variation between the ethyl ester of rice bran oil and diesel. The figure also shows the variation for rice bran oil where the increase in the exhaust gas temperature is due to the poor volatility and high viscosity of the fuel which has lead

International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 1, pp: 52-57 22nd March 2014

to poor combustion. The exhaust gas temperature for the ethyl ester of rice bran oil is 414^{0} C while that of diesels is 397^{0}**C.**

V. Conclusion

From the evaluation and comparison of the various types of fuels that have been experimented with in the single cylinder diesel engine, it is inferred that the rice bran oil is suitable for running compression ignition engines. To be more specific, the ethyl ester of rice bran oil (which is obtained upon the trans-esterification of pure rice.bran oil) is the most suitable for running automobiles in day to day life. This is due to the fact that performance of the ethyl ester of rice bran oil is on the same lines as that of diesel. So it is concluded that rice bran oil with diesel blends or ethyl ester of rice bran oil can be used as a automotive fuel. As straight rice bran oil emits more pollutants compared to all other blends it can be used as a engine fuel only after suitable modification.

REFERENCES

i. Yasufumi Yoshimoto *et al* (2001) "Cotton methyl ester usage in a diesel engine equipped with insulated combustion chamber," Applied Energy, 87, pp. 134–140.

ii. Masataka Hashimoto *et al* (2001) JEVTIC.,Djuro BORAK., 2009, and Velimir PETROVIC., "Potentials and limitations of alternative fuels for diesel engine," *Thermal science*, Vol. 13, No. 3, pp. 175-183.

iii. Lapuerta M., Armas O., Garcı´a-Gontreras R., 2007, "Stability of diesel–bioethanol blends for use in diesel engines," Fuel, 86, pp.1351–1357.

iv. Ozer Can., IsmetCelikten., and NazimUsta., 2004, "Effects of ethanol addition on performance and emission characteristics of a turbocharged indirect injection diesel engine running at different injection pressures," Energy Conversion and Management, 45, pp.2429-2440.

v. AndrzejKowalewic., 2004, "emission characteristics of compression ignition engine fuelled with RME/DF and ethanol," Journal of KONES internal combustion engines, Vol 11. No 1-2, pp349-357.

vi. Jincheng Huang., Yaodong Wang., Shuangding Li., Anthony P., Roskilly., Hongdong Yu., and Huifen Li., 2009, "Experimental investigation on the performance and emissions of a diesel engine fuelled with ethanol-diesel blends," Applied Thermal Engineering, Volume 29, Issues 11-12, Pp. 2484-2490.

vii. Pang X., Shi X., Mu Y., He H., Shuai S., Chen H., and Li R., 2006, "Characteristics of carbonyl compounds from a diesel-engine using biodiesel–ethanol–diesel as fuel," Atmospheric Environment, 40, pp.7057–7065.

viii. Lin, C.-Y., and Wang, K.-H., 2003, "The fuel properties of three phase emulsions as an alternative fuel for diesel engines," Fuel, **82**, pp. 1367-1375.

ix. KraipatCheenkachorn, Monpilai, H., Narasingha and JuthawanPupakornnopparut., 1-3 December 2004, "Biodiesel as an Additive for Diesohol," The Joint International Conference on Sustainable Energy and Environment (SEE), HuaHin, Thailand, 3-002 (O), pp 171-175.

x. Ribeiro, N. M., Pinto, A.C., Quintella, C.M., da Rocha, G.O., Teixeira, L.S., Guarieiro, L.L.N., Rangel M., Veloso, M.C.C., Rezende, M.J.C., Da Cru, R.S., Oliveira, A.M., Torres,E.A., de Andrad, J.B., 2007, "The role of additives for diesel and diesel blended (ethanol or biodiesel) fuels: a review," Energy & Fuels 21, pp. 2433–2445.

xi. Syed AltafHussain., Venkatasubbaiah, G., and Pandurangadu, V., May - July 2009, "Performance and emission characteristics of a supercharged direct injection diesel engine using rice bran oil,"*i-manager's Journal on Future Engineering & Technology*, Vol. No. 4 l pp.48-53.