EXPERIMENTAL ANALYSIS ON THE BLENDS OF BIODIESEL-TYRE PYROLYSIS OIL IN A DI DIESEL ENGINE

[1]Tanweer Hasan, [2]Anurag Bagri
[1]M.Tech Scholar, [2]Assistant Professor
[1]Mechanical Engineering Department
[1,2]Rabindranath Tagore University, Bhopal, India.

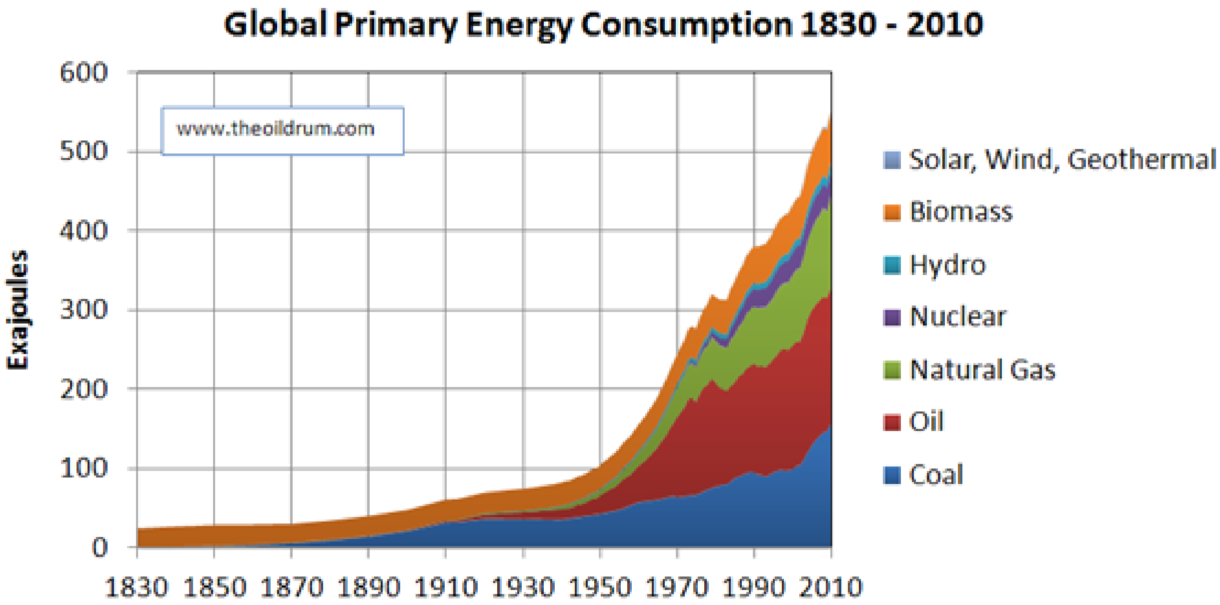
Abstract : In last four decades, the depleting petroleum reserves and tough emission regulations have driven the engine technology towards the research the different alternative fuels and power generating systems. The developing activities are going through the serious of measures for achieving higher thermal efficiency with lower exhaust emissions from engine. Also, researchers have tried to convert different waste material as a fuel for diesel engine application. The aim of the present research work is to investigate the potential utilization of fuel obtained by using waste tires as a feedstock for one of the thermochemical methods. The Jatropha biodiesel and fuel obtained by pyrolysis process were blended with diesel (5, 10, 15 and 20% by volume) and experiments were done in a diesel engine to evaluate their performance in terms of BTE, BSEC and EGT. The other emission parameters such as NO, Smoke, HC and CO were also recorded to check its physical significance.

Index Terms - **Biodiesel; Diesel Engine; Pyrolysis; Waste to Energy; Efficiency.**

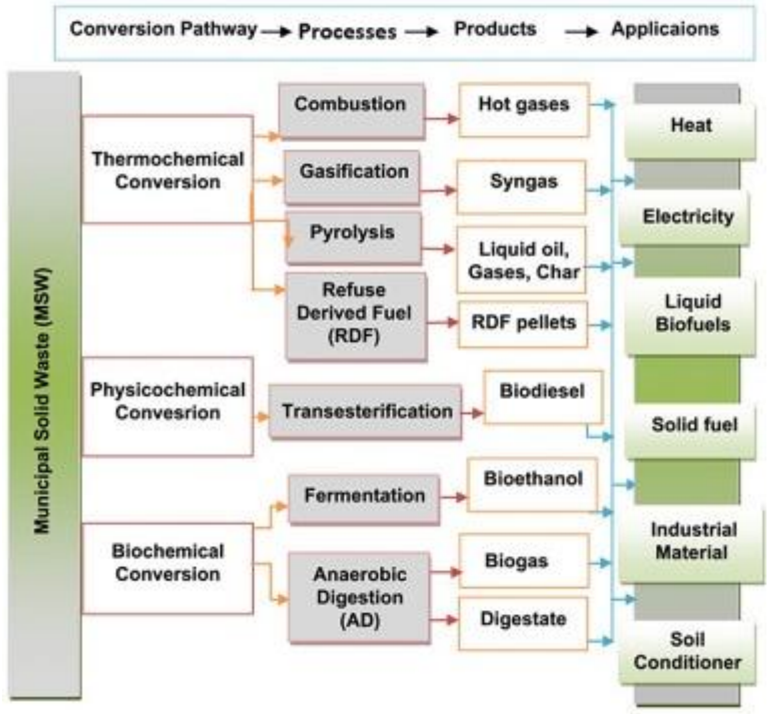
I. INTRODUCTION

To find out clean fuel for transportation and power generation and other application is very much necessary for survival. Research activities are going on these areas. Public concern towards maintaining a clean environment has motivated extensive research into the sources of pollution and ways to reduce it. Internal combustion engines are the major polluting contributors. Experimental works aimed at good fuel economy and lower tailpipe emissions involves frequent changes in the operating parameters concerned, which will be a time and money consuming module. Alternatively, in this computers era, simulation of engine combustion with a mathematical model can be done easily by considering the effects of design and changes in the operating parameters in short period of time. Various engine combustion models such as zero dimensional, quasi-dimensional and multi-dimensional models have been developed by many researchers to solve the complex heterogeneous combustion process of diesel engines [1-5].

Biodiesel is one of the prominent alternative fuels for many applications. In India many researchers have tried with different kind of vegetable oils for biodiesel production [6]. Also many tests have been done to convert waste products into useful form of energy. The world energy consumption is given in Fig.1.



In our country we encourage the use of non-edible oils for biodiesel production. Among the non-edible seeds produced in India, Jatropha is the most preferred because of its high oil content and biodiesel yield [7]. Also waste to energy has gained attention. The waste to energy technique has been described by using Fig.2.



In the current study fuel derived by pyrolysis of waste tire and Jatropha biodiesel are used for the replacement of diesel fuel by some percentage. The experiments were carried out in diesel engine and the results were analyzed in terms of performance parameter such as BTE, BSEC and EGT and emissions of HC, CO, NO and smoke etc. and compared with those of diesel operated engine.

II MATERIALS AND METHODS

The Jatropha biodiesel (JB) was produced by the tranesterification process which is known as the most efficient process of converting oil into biodiesel. Tranesterification process is also known as alcoholysis and this process is used worldwide for reducing the viscosity of vegetable oils.

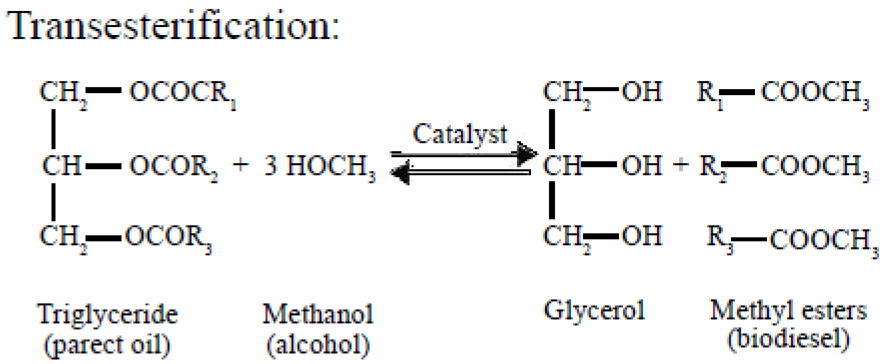
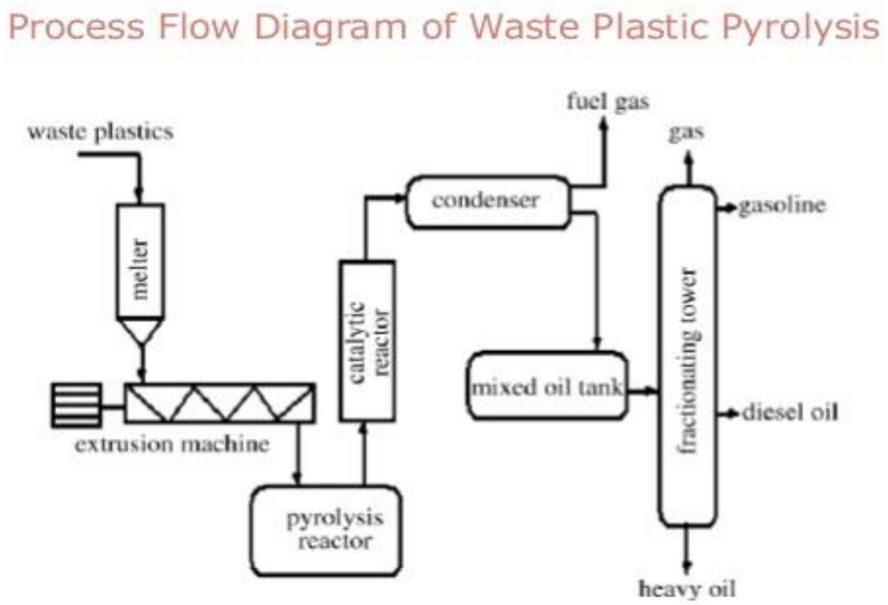


Figure 1: Transesterification reaction.

The other test fuel was derived by the pyrolysis process. The feedstock was used tires. Both the fuels were blended with diesel to get test fuels for the current study.



The test fuels designations are given below.

Fuel	JB (by volume)	WTDL (by volume)	Diesel (by volume)
diesel	-	-	100%
JB	100%	-	-
B5	5%	5%	90%
B10	10%	10%	80%
B15	15%	15%	70%
B20	20%	20%	60%

III Experimentation

Tests have been conducted in a diesel engine to test different types of fuels. The specifications of test engines are given in Table 3. Figure 2 shows the schematic diagram of the experimental set up.

Table 1 Engine specifications

Type	Kirloskar TAF1 Vertical diesel engine
No. of cylinder	1
Type of injection	Direct
Rated power at 1500 rpm, kW	4.41
Bore, mm	87.5
Stroke, mm	110
Compression ratio	17.5
Displacement volume, litres	0.662
Fuel injection timing bTDC, °CA	23
Number of injector nozzle holes	3
Nozzle-hole diameter, mm	0.25
Inlet valve opening bTDC, °CA	4.5
Inlet valve closing aBDC, °CA	35.5
Exhaust valve opening bBDC, °CA	35.5
Exhaust valve closing aTDC, °CA	4.5
Type of fuel injection	Pump-line-nozzle injection system
Connecting rod length, mm	220

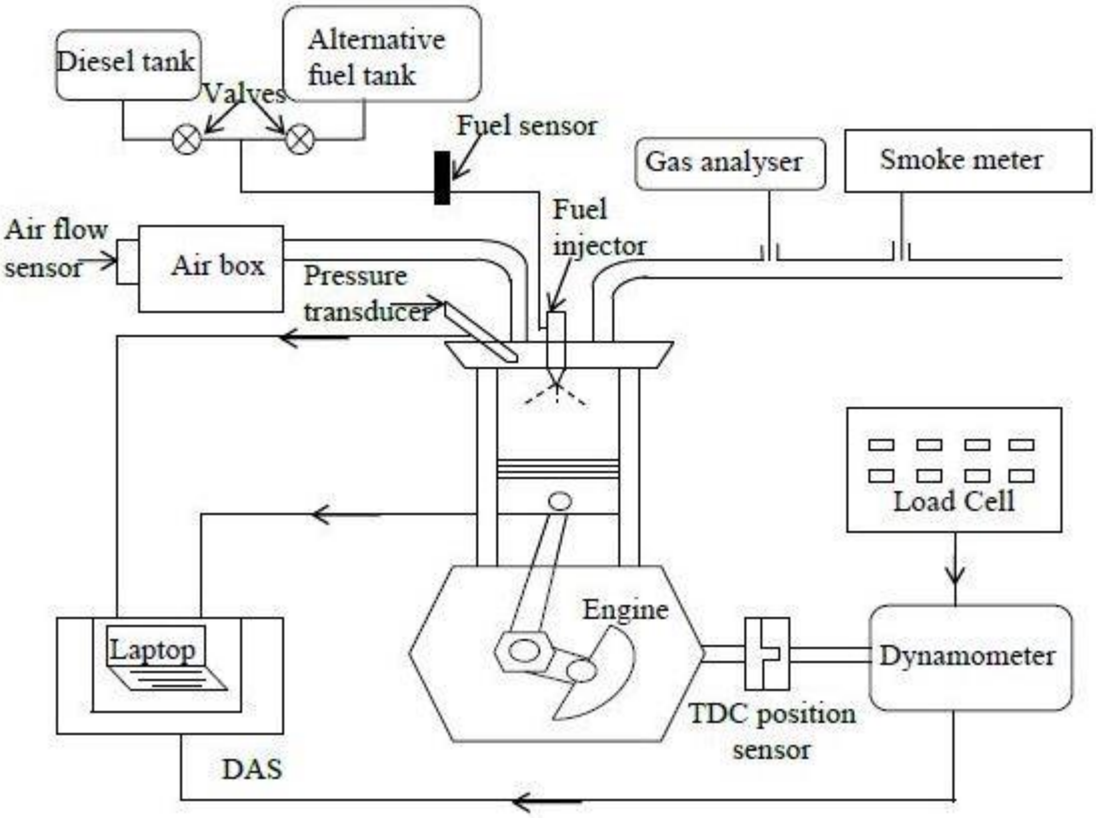


Figure 2 Schematic diagram of experimental setup

IV Results and Discussion

This section discusses the results of the performance and emission parameters obtained from the test engine run on diesel, JB and different diesel-JB-WTDL blends.

Brake Thermal Efficiency

The brake thermal efficiency gives information regarding how efficient the energy in the fuel was converted in to power output [8]. Figure 1 presents the power performance of the diesel and different test fuel blends derived engine under different loading conditions. It can be seen that under the same load, the greater efficiency is for diesel operated engine. In addition, the engine power increased linearly with the load for all the test fuels. As the load increases the heat generated in the cylinder increases, and hence, the brake thermal efficiency increases.

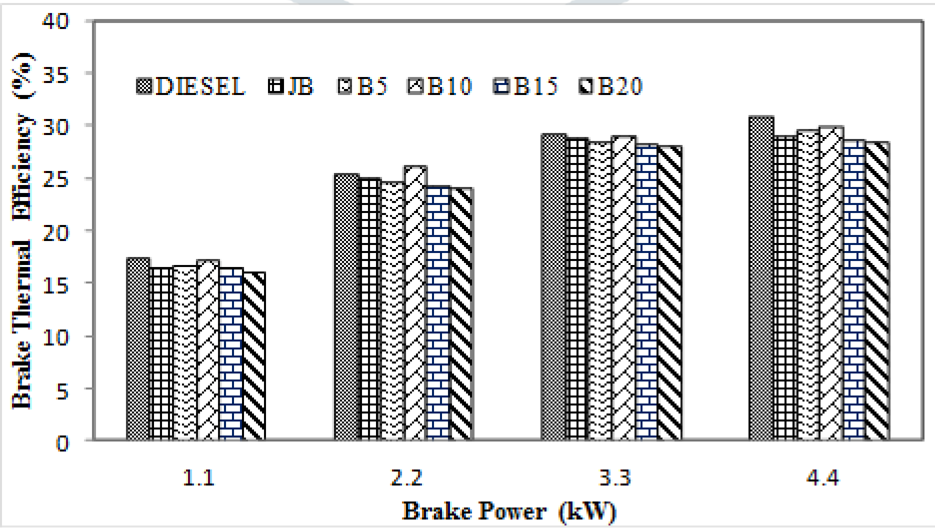


Fig.1 Variation of brake thermal efficiency with brake power

At full load the diesel gave highest brake thermal efficiency compared to all the test fuels used in the present study. This can be pertained to the higher calorific value of the diesel fuel compared among all test fuel used. The poor atomization of test fuels due to the higher viscosity may also be one of the causes for lower brake thermal efficiency than that of diesel. Among blends B20 produces highest brake thermal efficiency.

Carbon Monoxide Emission

The carbon monoxide (CO) emission characteristics of the engine run on diesel and different test fuel blends is presented in Fig. 2. It is known that the rate of CO emission is a function of the unburned fuel availability and mixture temperature, which controls the rate of fuel decomposition and oxidation. In the presence of sufficient oxygen, the CO emission is converted into carbon dioxide emission [9]. The value of CO emission at full load for the diesel, JB, B5, B10, B15 and B20 blend was found to be 0.044, 0.035, 0.037, 0.04, 0.046 and 0.052%.

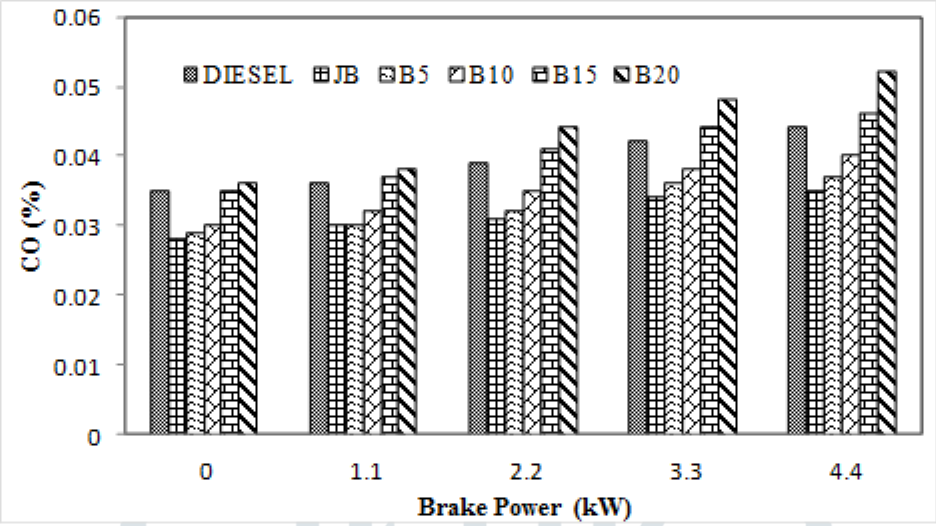


Fig.2 Variation of carbon monoxide emission with brake power

The CO emission for the JB, B5 and B10 is marginally lower than those of diesel fuel. This could be due to the fact that JB contains excess oxygen which helps for better combustion. When the percentage of tire derived fuel increases beyond 10%, the CO emission increases drastically. This may be due presence of aromatic content which results in incomplete combustion, and may lead to higher CO emission [10].

Hydrocarbon Emission

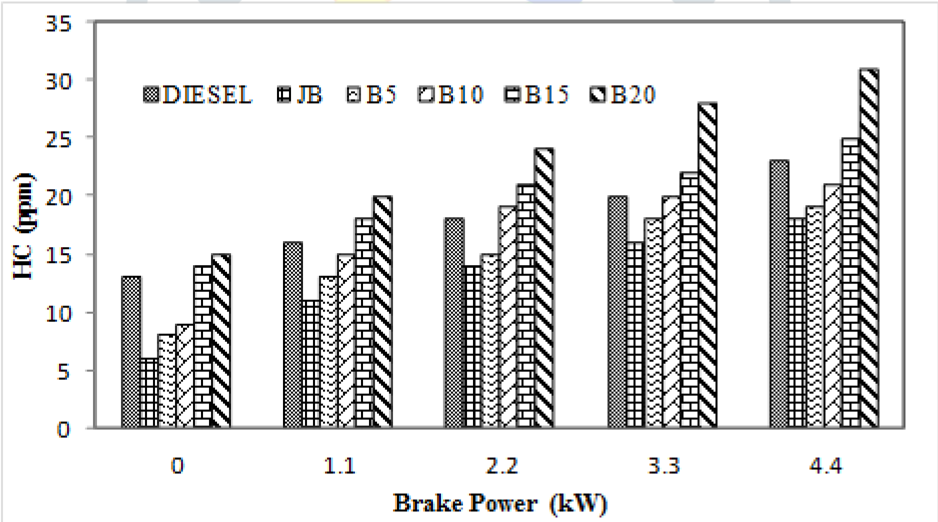


Fig.3 Variation of the unburnt hydrocarbon emission with brake power

The variation of hydrocarbon (HC) emission for diesel, JB and different test fuel blends is shown in Fig. 3. It is observed that hydrocarbon emission increases with the increase in percentage of WTDL in the diesel-JB-WTDL blends. The HC emission is lowest for JB and it was about 18 ppm at full load operation. This can be due to oxygen molecule present in biodiesel [11]. The highest value of HC emission was obtained with B20 blend and was noticed to be 31 ppm.

But the addition of the tire derived liquid percentage results in higher HC emission. This is due to the fact that TPO has higher aromatic content, and hence may result in incomplete combustion and more HC emission for B15 and B20 compared to the other test fuels used in this study. The HC values for diesel, JB, B5, B10, B15 and B20 23, 18, 19, 21,25 and 31 ppm are at full load.

Nitric Oxide Emission

The nitric oxide (NO) emission characteristics of the diesel and different test fuel blends derived engine at different load conditions are presented in Fig.4. It can be seen that the NO emission concentration increased with the load for all the test fuels.

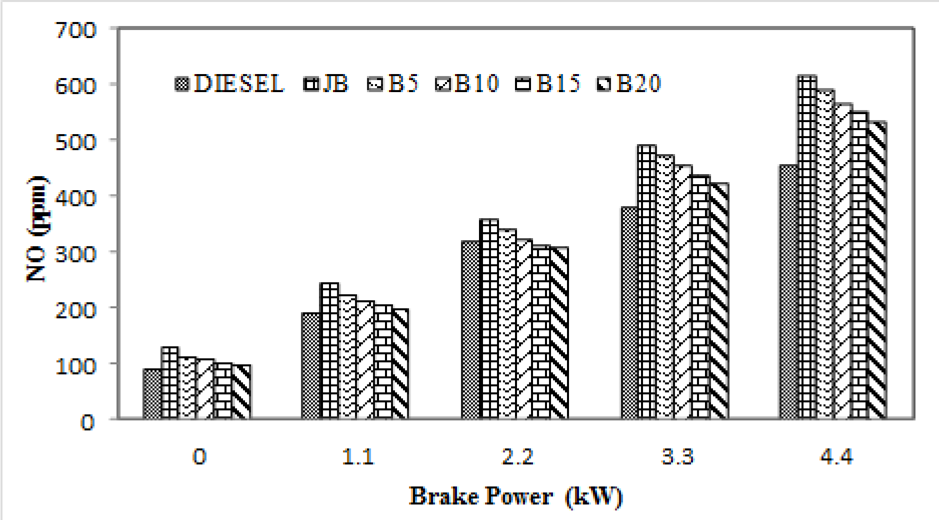


Fig.4 Variation of the nitric oxide emission with brake power

This is due to the fact that, because with increasing load, the temperature prevailing in the combustion chamber increases [12-17]. The NO emission form engine exhaust is highly dependent on oxygen concentration and combustion temperature. The JB has about 11% oxygen molecule which is the major cause of higher NO emission for this fuel compared to all other test fuel used in this study. While increasing the WTDL percentage in the blend, the NO emission decreases, because of lower heat release rates than that of JB. The values of NO emission for diesel, JB, B5, B10, B15, and B20 are by about 452, 614, 589, 564, 549, and 532 ppm respectively, at full load operation.

V Conclusions

In this research study we have done test on a diesel engine to check the use of fuel obtained by pyrolysis process. The summary of the tests are given below.

- The BTE of the engine was highest for the diesel and among different blend B10 gave higher BTE. At full load, the BTE is almost the same, i.e., 29.9% and 30.8% for B10 and diesel respectively, at full load.
- The CO and HC emissions were lower by about 9%, 19% respectively for B10, compared to diesel at full load.
- NO emission was higher by about 21% for B10 in comparison with diesel at full load.
- Overall it was noticed that any diesel engine can be run on this fuel without any difficulty. The results from the experiments prove that B10 blend is good substitute for diesel fuel.

REFERENCE

[1] Biswas PK, Pohit S, Kumar R. Biodiesel from Jatropha: can India meet the 20% blending target? Energy Policy 2010; 38:1477-84.

[2] Ghadge SV, Raheman H. Biodiesel production from mahua (Madhuca Indica) oil having high free fatty acids. Biomass and Bioenergy 2005; 28:601-605.

[3] Srivastava PK, Verma M. Methyl ester of karanja oil as alternative renewable source energy. Fuel 2008; 87:1673-1677.

[4] Nwafor OMI. Emission characteristics of diesel engine operating on rapseed methyl ester. J Renew Energy 2004; 29:119-29.

[5] Ramadhas AS, Jayaraj S, Muraleedharan C. Biodiesel production from high FFA rubber seed oil. Fuel 2005; 84:335-40.

[6] Demirbas A. Biodiesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other methods: a survey. Energy Combustion 2005; 44:2093-109.

[7] Achten WMJ , Verchot L, YJ Franken, Mathijs E, Singh VP , Aerts R , Muys B. Jatropha bio-diesel production and use. Biomass and Bioenergy 2008; 32: 1063-1084.

[8] Sharma A, Murugan S. Investigation on the Behaviour of a DI Diesel Engine Fueled with Jatropha Methyl Ester and Tyre Pyrolysis Oil Blends. Fuel 2013; 108:699-708.

[9] Agrawal AK. Biofuels (alcohols and biodiesel) Applications as Fuels for Internal Combustion Engines. Energy and Combustion Science 2007; 33:233-271.

[10] Reisman JI. Air Emission from Scrap Tyre Combustion. October, 1997, EPA-600/R-97.

[11] Yu CW, Bari S, Ameena A. Comparison of combustion characteristics of waste cooking oil with diesel as fuel in a direct injection diesel engine. J Automobile Eng 2002; 216:237–43.

[12] Chauhan BS, Kumar N, Cho HM. A study on the performance and emission of a diesel engine fueled with jatropha biodiesel oil and its blends. Energy 2012; 37:616–22.

[13] Kumar MS, Ramesh A, Nagalingam B. A comparison of the different methods of using Jatropha oil as fuel in a compression ignition engine. Journal of Engineering for Gas Turbines and Power. 2010 Mar 1;132(3):032801.

[14] Puhan S, Saravanan N, Nagarajan G, Vedaraman N. Effect of biodiesel unsaturated fatty acid on combustion characteristics of a DI compression ignition engine. Biomass and bioenergy. 2010 Aug 31; 34(8):1079-88.

[15] Jindal S, Nandwana BP, Rathore NS, Vashistha V. Experimental investigation of the effect of compression ratio and injection pressure in a direct injection diesel engine running on Jatropha methyl ester. Applied Thermal Engineering. 2010 Apr 30; 30(5):442-8.

[16] Rao GA, Mohan PR. Effect of supercharging on the performance of a DI Diesel engine with cotton seed oil. Energy Conversion and Management. 2003 Apr 30; 44(6):937-44.

[17] Karaosmanoğlu F, Kurt G, Özaktaş T. Long term CI engine test of sunflower oil. Renewable energy. 2000 Feb 29; 19(1):219-21.