IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 16, Issue 3 Ser. II (May. - June. 2019), PP 06-12
www.iosrjournals.org

Experimental Investigation on Performance of C.I. Engine with Jatropha Oil in Variable Proportions with Diesel

Bhagwat Prasad Dwivedi[1], Ajay Singh[2], Rajiv Varshney[3]
[1]*Research scholar, Department of Mechanical Engineering, Radharaman Institute of Research and Technology, Bhopal (M.P.)*
[2]*Prof.and Head, Department of Mechanical Engineering, Radharaman Institute of Technology and science, Bhopal(M.P.)*
[3]*Director, Radharaman Institute of Research and Technology, Bhopal (M.P.)*
*Corresponding Author: * Bhagwat Prasad Dwivedi1*

Abstract: *Increase in energy demand and oil prices stringent exhaust emission standards and reduction of oil reserves initiated the researchers to explore some new fuels for IC engines. Biodiesel is a substitute fuel to diesel fuel and can be used in IC engines to minimize exhaust emissions which in turn, helps in reduction of environmental degradation. But the major problem with biodiesel usage as fuel is the release of higher NOx emissions compared to diesel. Biodiesel is prepared from the transesterification of jatropha oil. Lots of research has been done and still going on alternative fuels like biodiesel, bio-alcohol and other biomass sources. The oil extracted from jatropha seeds by the pyrolysis process is considered as one of the alternative fuel for CI engine. However, it cannot be used directly in a CI Engine due to high viscosity, poor inflammability, low calorific value and corrosion of components. In order to solve these problems it has to be blended with diesel. In the present study, bio-oil from jatropha seeds is extracted by fixed bed machine process. It is blended with jatropha biodiesel with 0%, 15%, 30%, 45% and 60% on volume basis with diesel. The performance, emission and combustion characteristics of fuel blends are analyzed and compared with pure diesel and biodiesel. It is observed from results that the maximum brake thermal efficiency is recorded for J15 (Jatropha biodiesel 15% and pure diesel 85%) which is 23.42% at a brake power of 3.9 kW while for diesel it is 24.76%. It is minimum for J60 (Jatropha biodiesel 60% and pure diesel 40%) which is 19.23% and is more than pure diesel. All emission parameters like CO, $CO_{2,}$ HC, and NO_x are less emitted as compared to pure diesel.*
Keywords: *Jatropha oil, biodiesel, fuel properties, engine emissions.*

Date of Submission: 09-05-2019 Date of acceptance: 25-05-2019

I. Introduction

The continuously increase in energy demand with economic and environmental consequences call for effective energy governance in India. In the progress of the world's societies and future of earth, availability of energy resource play a critical role [1]. The human energy needs are currently fulfilled by petro-chemical sources, coal and natural gases, but these fossil fuels are continuously depleting and have damaging effect on environment. Energy consumption of world-wide has increased by 3-4 times in the last century. Power availability in India has increased and upgraded but demand was still more than the supply. Diesel fuel produces about 35000 MW of power to overcome the energy shortage [2]. Shortage of electricity is a serious issue. Electricity generation is subjected to expensive power plant. Social, environmental and technological benefits, are the some of the criteria for the selection of energy source [3]. A large degree of caution is also needed for struggling country like India which may not have financial assets to jump directly to renewable source of energy. Global warming is a major phenomenon and there is an urgent requirement for the transfer of technology from non-renewable energy to renewable energy sources [4].

1.1 Refining of Jatropha Oil.

After oil expelling, from the jatropha seeds contain some of the impurities such as uncrushed seed cake and other particulates. Therefore, it is essential to refine the crude vegetable oils. The crude non-edible oils such as Jatropha oil are refined in the laboratory through The Jatropha refined oil was then converted into biodiesel via a transesterification process. The transesterification process was done by adding NaOH (0.4% wt of oil) which was used as catalyst, and methanol (12.5% wt of oil) into the refined oil. The reaction temperature was selected at 50^o C and allowed the contact for an hour. After that, the mixture was left in the separation funnel overnight. The glycerine was removed and the biodiesel was washed with warm de-ionized water before analyzing for its properties.. temp of 600^oC for 4 hours to remove the traces of moisture. The dried oil was stored in the air tight dry PVC cans. The oils were filled up to the brim of the can to avoid any chances of oxidation [5]. These cans are stored in a room at ambient temp.The triglyceride is step wise converted to diglyceride, menoglycerides, and finally glycerol through chemical reactions [6] .

II. Literature Survey

Bhaskar et al. [9] performed a study on emission characteristics of biodiesel obtained from Jatropha seeds and fish wastes in a diesel engine. This study emphasizes on the reuse of fish waste and use of waste land for cultivation of Jatropha seeds. By this study, we come to know that using blends of biodiesel obtained from Jatropha seeds, exhaust gas temperature and NOx are observed to be higher for these fuels compared to diesel.

Shivaramakrishnan [10] carried out an investigational study on performance and emission characteristics of a variable compression multi fuel engine fuelled with Jatropha biodiesel–diesel blend. This investigation was summarised for the performance and emission of a single cylinder four stroke diesel engines when fuelled with 20%, 25% and 30% of Jatropha blended with diesel and compared with standard diesel. It results the performance of jatropha biodiesel is very close to pure diesel .

Acharya et al. [11] studied the stability characteristics of Mahua and Jatropha biodiesel and their blends. This comparative study emphasized on the oxidation and storage stability of Mahua and Jatropha biodiesel. The presence of more unsaturated fatty acid (76.8%) in Jatropha biodiesel than in Mahua biodiesel (58.81%) makes the Jatropha biodiesel more prone to oxidation and the induction period of Jatropha biodiesel is lower as compared to that of Mahua biodiesel.

Rao [12] conducted an investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with Jatropha biodiesel–diesel. This research results as experimental investigations on a single cylinder, direct injection, diesel engine using diesel-biodiesel blends with cetane improver Ethyl Hexyls Nitrate as an additive under different Exhaust Gas Recirculation conditions, with increase in EGR percentage CO_2, CO emissions were found to be increased while HC, NOX emissions were decreased.

Deivajyothi et al. [13] performed a study on impact of ethyl esters of groundnut acid oil (vegetable oil refinery waste) in DI diesel engine in. As a result, the specific fuel consumption is minimum (0.264 kg/kWh) for (Biodiesel 20% with Ethyl Ester of Groundnut Acid Oil) B20EEGAO at maximum load. The calorific value decreasing with increase in EEGAO blends. At full load, B20EEGAO has the higher brake thermal efficiency of 29.90% compared to other biodiesel blends. This could be ascribed to the content of more amount of oxygen in B20EEGAO, which may have brought about its enhanced burning. There is lower in smoke density for B20EEGAO (40.3 HSU) compared to diesel (43 HSU) at maximum load.

Redel Macias et al. [14] performed an investigational study on ternary blends of diesel fuel oxygenated with ethanol and castor oil for diesel engines. This study emphasized the main drawback of its use as fuel is its poor solubility when it is blended with diesel fuel. Although additives are used to improve its miscibility. The use of castor oil as additive to increase the miscibility of ethanol/diesel fuel blend is proposed. It was found that higher the ethanol content, lower the kinematic viscosity and HCV, although the higher the presence of castor oil the higher the cold filter plugging point (CFPP) values. It has also been observed that the higher the percentage of ultra low diesel sulphur (ULSD) the higher the value of HCV.

Markov et al. [15] performed an investigational study on optimization of Diesel Fuel and Corn Oil Mixtures Composition. Study of a diesel engine performance with exhaust gas recirculation (EGR) system fuelled with palm biodiesel, mineral diesel and palm biodiesel operated with two different modes (EGR and normal) in a diesel engine at full load at 2500 rpm was carried out. Increases in fuel economy are obtained with the use of palm biodiesel and EGR employment at the specific engine speed. This research reveals that there was a decrease in the exhaust gas temperature when the EGR is employed for both test fuels. When the EGR is applied NOx emission is reduced significantly with increases in CO and UHC emissions for both test fuels.

III. Experimental Procedure

The tests were conducted on a single cylinder four-stroke naturally aspirated water cooled diesel engine loaded with a rope brake dynamometer. The technical specification of the engine used for the investigation are given in table 3.1

3.1 Test Setup Specification

A single cylinder 4-stroke water-cooled direct injection diesel engine is used for investigation.

Table 3.1 Engine Specification

Engine parameter	Specifications
Engine	4-Stroke Single cylinder (Diesel Engine)
Rated Power	5 BHP
Speed	1500 rpm
Bore	87.5 mm
Stroke	110 mm
Volume	661 cc
Nozzle Type	Single hole
Cooling system	Water cooled

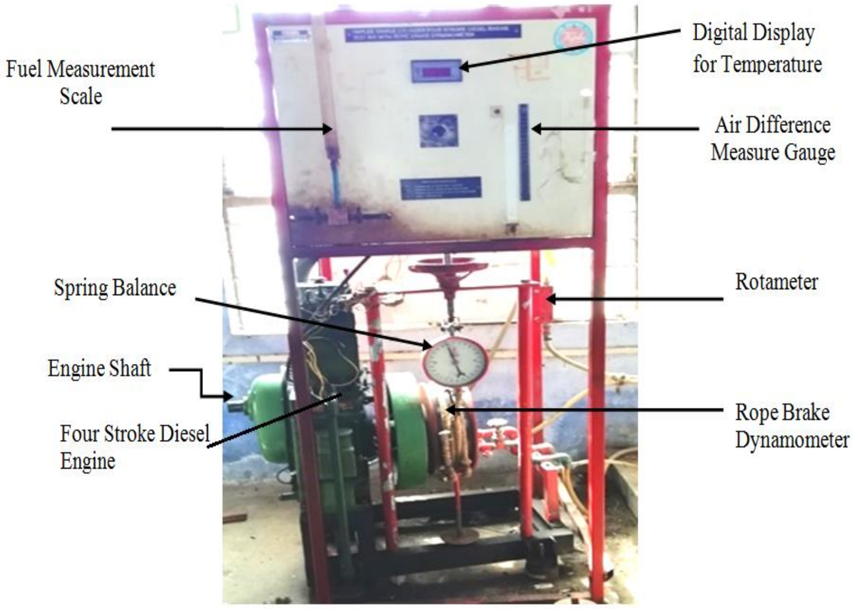

Fig.2 Actual view of experimental setup

The actual view of experimental setup is shown in Fig.2 The setup consists of single cylinder engine coupled with rope brake dynamometer. The dynamometer is used to load and unload the engine as per experiment requirement. In order to measure revolution of the engine shaft a sensor is coupled with the shaft to count the rpm of the shaft, and for measuring various exhaust the test engine is connected with a exhaust sensor. A sensor is coupled with the exhaust pipe outlet to sense various contents of exhaust gas and sent the result to CPU which in turn shows the results on the monitor screen. For cooling external jacket of the engine is coupled with water source. And the fuel tank is coupled with engine to supply the fuel to the cylinder.

Experiments were conducted with esterified Jatropha oil and diesel blends having 0%, 15%, 30%, 45% and 60% esterified Jatropha oil on volume basis at different load levels. Tests of engine performance on pure diesel were also conducted as a basis for comparison. The percentage of blend and load, were varied and engine performance measurements such as brake specific fuel consumption, air flow rate, and emissions were measured to evaluate and compute the behavior of the diesel engine. Each time the engine was run at least for few minutes to attain steady state before the measurements were made. The experiments were repeated thrice and the average values were taken for performance and emission measurements.

IV. Results And Discussions

4.1 Effect f brake power on specific fuel consumption for different blending ratio

Variation of specific fuel consumption and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 3.

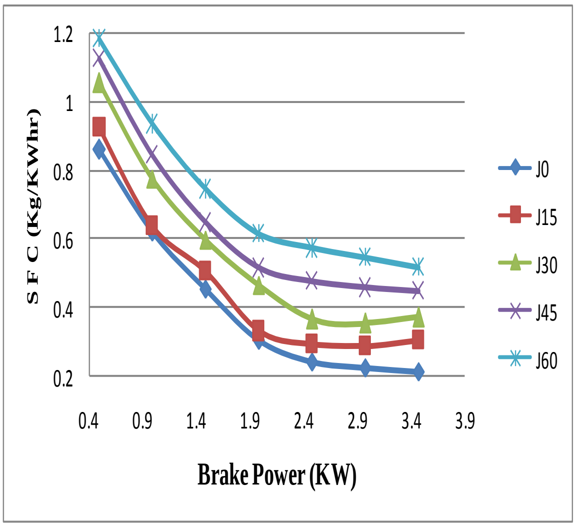

Fig.3 Effect of Brake Power on Specific Fuel Consumption For Different Blending Ratio.

Fig.3 shows that the specific fuel consumption increased as the blending ratio increased. Also, specific fuel consumption decreased with increase in brake power.

It is found that the specific fuel consumption for the blend B15 is close to diesel. However, if the concentration of Jatropha oil in the blend is more than 30% the specific fuel consumption is found to be higher than diesel at all loads. This is because of the combined effects of lower heating value and the higher fuel flow rate due to high density of the blends. Higher proportions of Jatropha oil in the blends increases the viscosity which in turn increases the specific fuel consumption due to poor atomization of the fuel [16].

4.2 Effect of brake power on brake thermal efficiency for different blending ratio

Variation of brake thermal efficiency and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 4.

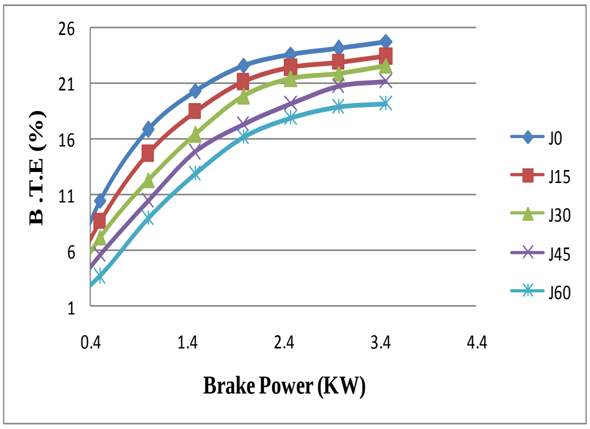

Fig.4 Effect of Brake Power on Specific Fuel consumption For Different Blending Ratio.

Fig.4 shows that the brake thermal efficiency decreases as the blending ratio increases. Also, brake thermal efficiency increases with increase in brake power [17]. It was observed that brake thermal efficiencies of all the blends are found to be lower at all load levels. Among the blends J15 is found to have the maximum thermal efficiency of 23.42% at a brake power of 3.9 kW while for diesel it was 24.76% and for B60 it decreased to 19.23%. It was observed that as the proportion of Jatropha oil in the blends increases, the thermal efficiency decreases. The decrease in brake thermal efficiency with increase in Jatropha oil concentration is due to the poor atomization of the blends due to their higher viscosity [18].

4.3 Effect of brake power on carbon dioxide for different blending ratio

Variation of carbon dioxide and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 5.

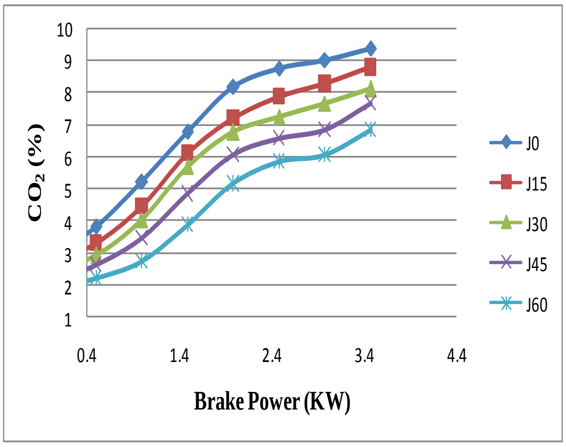

Fig. 5 Effect of Brake power on Carbon Dioxide for Different Blending Ratio.

Test results reveals that the CO_2 emission for all blends were less as compared to diesel at all loads. The increasing trend of CO_2 emission with load is due to the higher fuel entry as the load increases. Biofuels contain lower carbon content as compared to diesel and hence the CO_2 emission is comparatively lower [19].

4.4 Effect of brake power on carbon monoxide for different blending ratio Variation of carbon monoxide and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 6

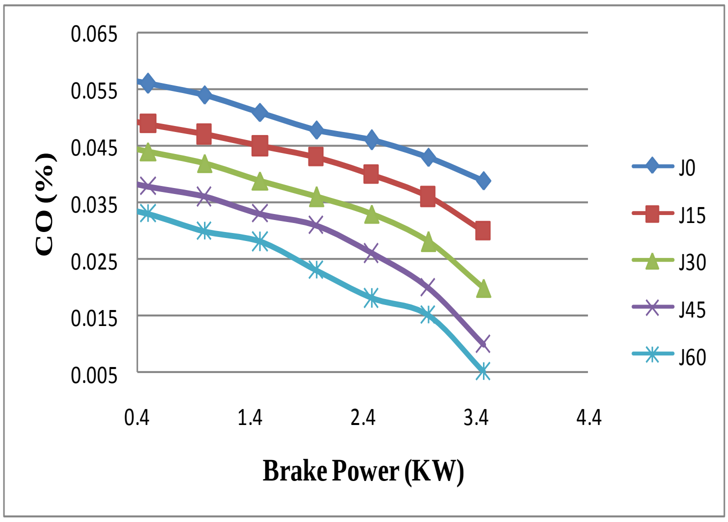

Fig. 6 Variation in carbon monoxide and brake power for different blending ratios

It was observed that the engine emits more CO for diesel at part load conditions when compared to the blends. But as the proportion of Jatropha oil in the blend increases the percentage of emission decreases. However, the percentage variation of carbon monoxide for all the blends when compared with base line diesel is very much less.

4.5 Effect of brake power on hydro carbon for different blending ratio
Variation of Hydro carbon and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 7.

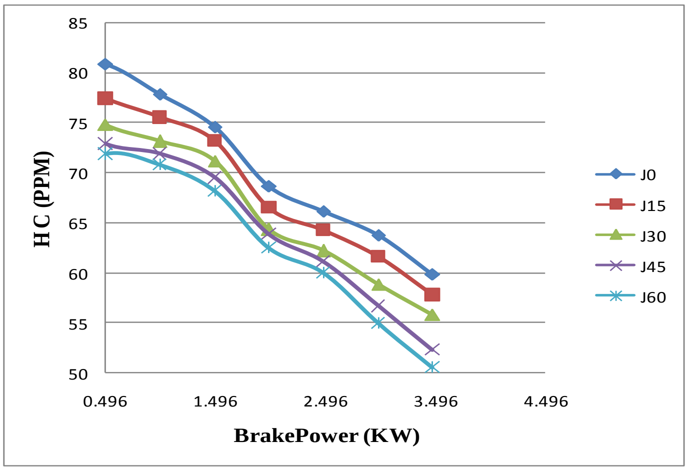

Fig. 7 Effect of Brake power on Hydro Carbon for Different Blending Ratio**.**

It was observed that the HC emission decreased up to a load of 2.1 kW and then increased slightly with further increase in load for diesel. The HC emission for the blends also followed a similar trend but comparatively the values were lower. The presence of oxygen in the Jatropha oil aids combustion and hence the hydrocarbon emission reduced. However at higher loads the effects of viscosity have increased these emission levels for the blends [20].

4.6 Effect of Brake power on Oxides of Nitrogen for Different Blending Ratio.
Variation of oxides of nitrogen and brake power for different blending ratios i.e. J0, J15, J30, J45 and J60 is shown in Fig 8.

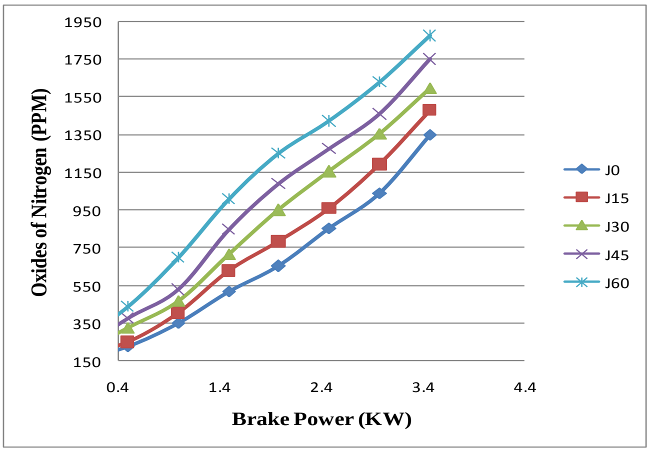

Fig. 8 Effect of Brake power on Oxides of Nitrogen for Different Blending Ratio**.**

The variation of NOx emission for different blends is indicated in Fig 8. The NOx emission for diesel and all the blends followed an increasing trend with respect to load. For the blends an increase in the emission was found at all loads when compared to diesel. NOx is formed generally at high temperatures. Since the exhaust gas temperatures are higher the NOx emissions are also higher [21].

V. Conclusion

The experiment was performed with single cylinder four stroke diesel Engine and results of blending of Jatropha oil and diesel were compared with the results obtained with pure diesel. The following are the major conclusions that are drawn.

1. The specific fuel consumption is closer to diesel for B15 among all the blends. Blends up to 15% substantially reduce CO_2 emissions with a marginal decrease in brake thermal efficiency.
2. The exhaust gas temperatures for J15 are higher than pure diesel , which in turn increased the NOx emissions.

3. A maximum brake thermal efficiency of 23.42% was achieved for J15 while for diesel it was 24.76% for the same power output. Experimental investigations show that blending of Jatropha up to 15% with diesel for use in an unmodified diesel engine is viable.
4. Jatropha biodiesel produced from renewable biomass resources are easily available in the market.
5. From the above findings, it can be concluded that we can sustain for the energy requirements for a larger period of time by using the blending of Jatropha biodiesel with pure diesel without much affecting the performance and exhaust emission characteristics.

References:

[1]. Monyem A., Gerpen J.H.V., Biomass and Bioenergy, 20 (2001) 317–325
[2]. Tormos B., Novella R., Garcia A., Gargar K., Renewable Energy, 35 (2010) 368–378)
[3]. Nurun Md., Rahman Md., Akhter Md., Applied Thermal Engineering ,29, (2009) 2265 -2270
[4]. Lapuerta M., Armas O., Fernandez F., Progress in Energy and Combustion Science, 34 (2008) 198
[5]. Roskilly P A., Nanda S.K., Wang D.W., Chirkowski J., Applied Thermal Engineering, 28, (2008) 872
[6]. Chauhan BS, Kumar N, Cho HM. Performance and emission studies on an agriculture engine on neat Jatropha oil. Journal of Mechanical Science and Technology 2010;24(2):529-35.
[7]. Chauhan BS, Kumar N, Pal SS, Jun YD. Experimental studies on fumigation of ethanol in a small capacity diesel engine. Energy 2011;36:1030-8.
[8]. Chauhan BS, Kumar N, Jun YD, Lee KB. Performance and emission study of preheated Jatropha oil on medium capacity diesel engine. Energy 2010;35: 2484-92.
[9]. Bhaskar Kathirvelu, Sendilvelan Subramanian, Nagarajan Govindan, Sampath Santhanam, Emission Characteristics of Biodiesel obtained from Jatropha seeds and fish wastes in a diesel engine ,2017 sustainable environment research 27 (2017) 283-290.
[10]. K. Sivaramakrishnan , Investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with Jatropha biodiesel–diesel blend.2017 Egyptian Journal of Petroleum 352 (2017) 246–589.
[11]. N. Acharya P. Nanda, S.Panda, S.Acharya, A comparative study of stability characteristics of mahua and jatropha biodiesel and their blends,2017 Journal of King Saud University Engineering Sciences.
[12]. K. Srinivasa Rao, Investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with Jatropha biodiesel–diesel,2017 blend.
[13]. P. Deivajothi V. Manieniyan S. Sivaprakasam , An impact of ethyl esters of groundnut acid oil (vegetable oil refinery waste) used as emerging fuel in DI diesel engine,2017 Alexandria Engineering Journal.
[14]. M.D. Redel-Macías S. Pinzib, D.E. Leiva-Candia, I. López, M.P. Dorado, Ternary blends of diesel fuel oxygenated with ethanol and castor oil for diesel engines, 2017 science Direct, Energy Procedia 142 (2017) 855–860.
[15]. V.A. Markov V.G. Kamaltdinov, S.S. Loboda, Optimization of Diesel Fuel and Corn Oil Mixtures Composition 2016, Science Direct, Procedia Engineering 150 (2016) 225 – 2.
[16]. Global concentrated solar power outlook e why renewable are hot!, http:// www.greenpeace.org/raw/content/international/press/reports/concentratingsolar-power-2009.pdf; 2009.
[17]. Pascal N, Mohand T. Use of palm oil-based biofuel in the internal combustion engines: performance and emissions characteristics. Energy 2011;33(3):1790e6.
[18]. Gumus M, Kasifoglu S. Performance and emission evaluation of a compression ignition engine using a biodiesel (apricot seed kernel oil methyl ester) and its blends with diesel fuel. Biomass and Bioenergy
[19]. Kegl B. Effects of biodiesel on emissions of a bus diesel engine. Bioresource echnology 2008;99(4):863e73.
[20]. Sahoo PK, Das LM, Babu MKG, Naik SN. Biodiesel development from high acid value polanga seed oil and performance evaluation in a CI engine. Fuel 2007; 84:448e54.
[21]. Agarwal D, Sinha S, Agarwal AK. Experimental investigation of control of NOx emissions in biodiesel-fueled compression ignition engine. Renewable Energy 2006;31:2356e69.
[22]. Canakci M. Combustion characteristics of a turbocharged DI compression ignition engine fueled with petroleum diesel fuels and biodiesel. Bioresource Technology 2007;98:1167e75.
[23]. Sampath Santhanam, Emission characteristics of biodiesel obtained from jatropha seeds and fish wastes in a diesel engine. Sustainable Environment Research,2017-283-290.

Experimental Investigation on Performance of C.I. Engine with Jatropha Oil in Variable Proportions with Diesel." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 16, no. 3, 2019, pp. 06-12.