Experimental Investigation of CI Engine Performance and Emission Characteristics by Effect of Nano Fuel Additives in Pongamia Pinnata Biodiesel

S.Manibharathi[1] R.Chandraprakash[2] B.Annadurai[3] R.Titus[4]
[1,2]P.G scholar [3,4]Assistant professor
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]R.V.S College of Engineering and Technology, Coimbatore, India

Abstract— The effect of Nano fuel additives on the performance and emission characteristics of CI engine fueled with a blend of Pongamia pinnata biodiesel and diesel. The ball milling process is used to prepare the Nano rhodium oxide (Rh2O3) particles. The Nano rhodium oxide (Rh2O3) particle size is characterized by using scanning electron microscope (SEM). The Nano rhodium oxide size obtained in the range of 100 NM. The Nano Rhodium oxide is circulated in the biodiesel with the help of magnetic stirrer with the surface concentration. Various proportions of Pongamia biodiesel blends (10%, 20% and 30%) were used for showing the performance and emission test at different load situations. A single cylinder, air cooled, direct injection diesel engine is used for the test. The addition of rhodium oxide Nano particles, with the biodiesel at different dosing levels of the additive showed an improvement in the efficiency of the engine. During combustion the additive release the energy in the fuel, reduce the energy consumption and improves the thermal efficiency. Metal additives quite effective in controlling NOx formation. With the help of fuel base metal additives is reduced HC emission and PM emission. The addition of Nano rhodium oxide additives in fuel it reduces NOx emission up to 17% at B20 when compare with B10 and B30. Also reduces the unburnt hydrocarbon (UBHC) up to 25% at B20.

Key words: Nano particles, pongamia biodiesel, Fuel additive, metal oxide, Rhodium oxide

I. INTRODUCTION

BIO DIESEL is an alternative fuel produced from non-edible oil seeds. The oil obtained from the seeds has high viscosity more than that of diesel. Biodiesel is receiving more attention due to increasing of crude oil price and decreasing oil reserves. Biodiesel is made by transesterfication of animal fat and vegetable oil. The production of biodiesel in India is non-edible oils obtained from species e.g.: Jatropha, Pongamia pinnata, polanga. The high cost of edible oils in India, non-edible oil is used for production of biodiesel. The advantage of the biofuel over the diesel fuel includes high cetane numbers low smoke and particulates, low carbon dioxide and hydrocarbon emissions. Biodiesel is Eco friendly for alternative fuel for diesel engine. The vegetable oil has high viscosity and low calorific value affects the spray formation of fuels. It has total combustion and less exhaust emissions than diesel fuel. The energy content of biodiesel is about 12% less than diesel fuel. Biodiesel Contains 10-15% of Oxygen. It is an Oxygenated fuel. The optimized blend of biodiesel and diesel has reduced some percentage of the world's dependence on fuels without modification of CI engine. A pure form of biodiesel can used in diesel engine it needs to require an engine modification. To avoid engine maintenance and performance problems we can use blends of biodiesel. A large quantity a Pongamia oil available in India. Pongamia oil is a good feedstock for production of biodiesel synthesis. In India 200 million tons of Pongamia oil produced per year [1]. A high percentage of polyunsaturated fatty acids, an average seed contain 28-34% of polyunsaturated fatty acid. An advantage of Pongamia pinnata oil is having oxygen content, cetane number and it is clean. Pongamia pinnata biodiesel having certain disadvantage lower performance and higher emission. The chemical substance is used to control the problem associated with biofuel, like fuel additives is consequent from organic and inorganic metal is used [2]. Nano additive is usually improves combustion efficiency and reduces the emission. Metallic compounds generally used as combustion catalyst for hydrocarbon fuel, like copper, iron, rhodium, zinc and platinum, etc.., recent technology in the nano field enables the production, nano particles are highly energetic materials. The Advantage for using nano particles is its size, due to the particles are micron sized so no chance of clogging.

The effect of additive based on a Vegetable oil combined with nano additive on exhaust emission of diesel engine fuelled with biodiesel [4]. Nano additives help the engine to burn fuel better and air has reduced Cu content. The reduce a temperature inside the cylinder during combustion, because the presence of nano additive in the blended fuel. It has also reduced a NO_x emission. Study to improve an ignition property of the diesel fuel and studied the influence of size and quantity of nano Al and Al_2O_3 particles in a fuel [5]. To conclude the possible of decreasing the evaporation time of droplets by the increasing heat and mass transfer properties of the fuel. The probability to increase the ignition of diesel and the shortens the ignition delay by adding additives. The transesterfication process is used to prepare a Pongamia biodiesel. The main advantage of the transesterfication process is reduced the high viscosity of oil is suitable for CI engine. Pongamia methyl ester is obtained by reacting Pongamia oil with methanol in the presence of the catalyst [1]. The chemical reaction for transesterfication process is shown in figure 1. In the present investigation is the addition of nano additive in a blend of biodiesel effect and also performance and emission characteristics was evaluated by a compression ignition engine.

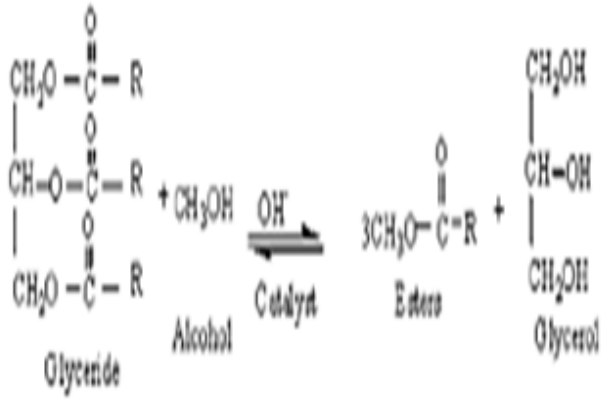

Fig. 1: Chemical Reaction to Transesterfication Process

II. PROPERTIES OF PONGAMIA BIODIESEL AND BLENDS

The biodiesel obtained from the Pongamia oil by transesterfication process. Then the biodiesel blends with diesel in three different portions, (10%, 20%, and 30% by volume). For obtaining Pongamia biodiesel blend B-10 90% of diesel are mixed with 10% of Pongamia oil by volume. B-20 contains 20% of biodiesel and 80% diesel by volume and b-30 contains 30% of biodiesel and 70% diesel by Volume. The properties of biodiesel and blend biodiesel are shown in Table 1.

Property	**B-10**	**B-20**	**B-30**	**B-100**	**Diesel**
Density (Kg/m^3)	847	852	866	890	850
Viscosity (40^oC) cst	4.3	4.1	5.6	3.5	4
Flash point ^oC	71	68	70	145	70
Calorific value KJ/g	40420.2	41136.8	38690.2	36120.3	42390

Table. 1: Properties of Fuel

III. NANO FLUID PREPARATION

Nano particles are prepared by a ball milling process. It works on the principle of impression size reduction is done by impact as the ball drop from close the top of the casing. Ball milling is a powder metallurgy processing technique involves grinding materials into exceedingly fine powder. Ball milling operates at 450 RPM to convert the rhodium oxide into nana rhodium oxide. The particle size in the range of 100 nm, the size is characterized by scanning electron microscope (SEM). The SEM image of nano rhodium oxide shown in figure 3.

Fig. 2: Ball Milling Machine

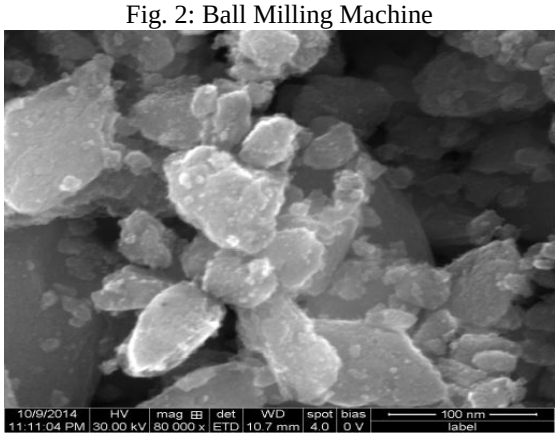

Fig. 3: SEM Image of Rhodium Oxide

Then the nano rhodium oxide was added to the biodiesel and concentration stability stood studied. The nano rhodium oxide was dispersed in the biodiesel by using a magnetic stirrer. Nano Rhodium Oxide generally has a higher surface area and they will tend to agglomerate to form a micro molecule and start to sediment. By using Cetyl Trimethyl Ammonium Bromide (CTAB), the nano particle sedimentation is organized. CTAB is a cationic surfactant; it is covered on the surface of nano rhodium oxide and produce a negative charge. The nano rhodium oxide is disperse to base magnetic stirrer procedure was followed.

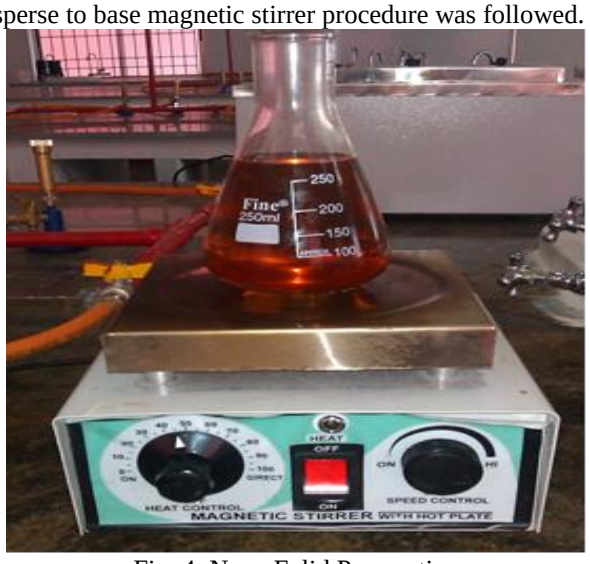

Fig. 4: Nano Fulid Preparation

A nano Rhodium Oxide is a corundum structure of a hexagonal form. When heat a rhodium oxide above 750 ^OC it transforms from a corundum structure to the

orthorhombic structure. It is a dynamic site for CO oxidation because nano rhodium oxide has a higher valence electron so it is highly unstable. A nano Rhodium oxide is extremely energetic materials and burns through the combustion process. Mechanism of CO depends on two kinds of oxygen. The mobility of oxygen is active clearly by thermal treatment. The temperature of the active oxygen is higher and the oxidation converts easier. The nano rhodium oxide has a lattice oxygen is more active than the oxygen and forms an intermediary. Rhodium oxide is coated with CTAB. The nano rhodium oxide particles form a layer and hence droplets shape is distended. High temperature of nano particles sudden explosion take place and the fuel is available in the main area of droplet (2) as show in Figure 6

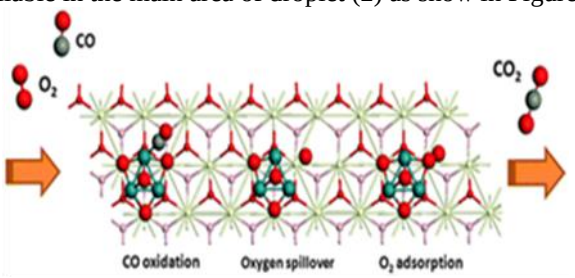

Fig. 5: Catalyst Mechanism.

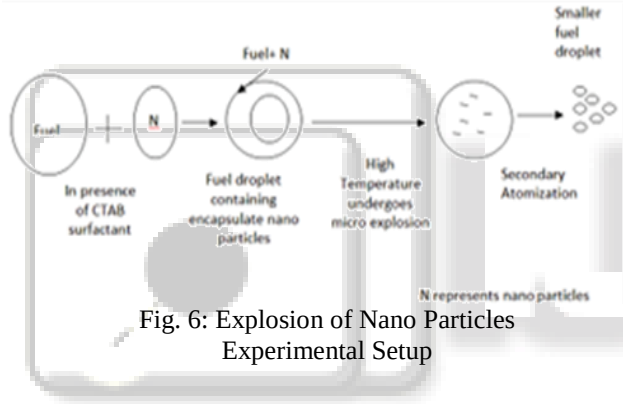

Fig. 6: Explosion of Nano Particles
Experimental Setup

IV. EXPERIMENTAL SETUP

Measuring the performance and emission characteristics of diesel and blends of biodiesel with additive and surfactant. Engine details are given in Table 2. A single cylinder, four stroke, air cooled, direct injection (DI) diesel engine was connected to an electrical dynamometer. The engine operated at speed 1500 rpm with compression ratio 17.5. The electrical dynamometer is used to measure a power output. Fuel consumption of time taken was measured with the help of the burette and stop watch. Thermocouple is used to measure the exhaust gas temperature. The thermometer and thermocouple are used measure an ambient temperature and exhaust gas temperature respectively. The speed is measured with the help of the tachometer. Exhaust gas analyzer is used to measure a exhaust gas such as CO, HC, NO_x. The effects are plotted against brake mean effective pressure (BMEP). The experimental setup is shown in the figure 7. BMEP 1 bar 2 bar and 3 bar are loads of the test engine

Type	**Single cylinder, four stores, air cooled, direct injection diesel engine**
Capacity	661 cc
Bore × stroke	87.5 mm × 110 mm
Compression Ratio	12:1 to 18:1
Speed	1500 RPM
Rated power	3.5 kw
Injection Timing	25 ^{0} btdc
Injection Pressure	220 bar

Table. 2: Engine Specification

Fig. 7: Expermental Setup

V. RESULT AND DISCUSSION OF ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS

A. Brake specific energy consumption (BSEC) vs. BTE:

Figure 8 shows the difference of brake specific energy consumption for blends of Pongamia oil with nano rhodium oxide additive and diesel with brake mean effective pressure at different load condition. The effect of nano rhodium oxide additive in the B-10 for BSFC is near to the diesel fuel. Diesel has a higher calorific value, compare with Biodiesel so it maintains the same output excess of fuel was consumed during neat biodiesel operation. The heating value and density of the fuels are different, so the fuel consumption may not dependable. The addition of nano particles resulted in a 3 % reduction in Brake specific fuel consumption at engine load because the catalytic chemical oxidation takes place into fuel which turn improves the fuel combustion.

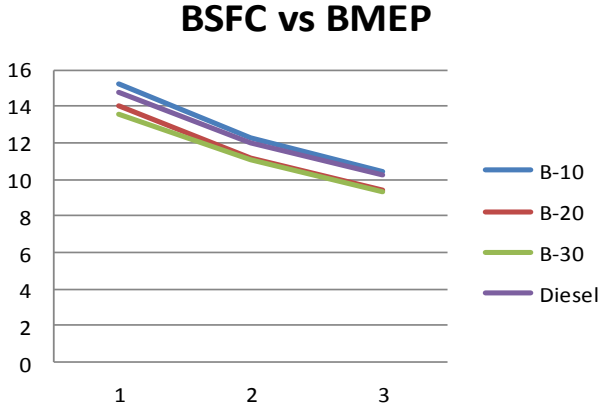

Fig. 8: BMEP Vs. BSFC

B. Brake Thermal Efficiency vs. BMEP:

The variances of brake thermal efficiency (BTE) for blends of Pongamia biodiesel with additive and diesel fuel with brake mean effective pressure (BMEP) are shown in Figure 9. When compared with diesel, biodiesel has lower volatility, lower heating value, higher viscosity and density so the brake thermal efficiency is lowest for B-20 & B-30 at all loading conditions. The fuel is typically converted into mechanical energy up to 15-20%. . The outstanding energy radiates into the air as waste heat. Blends of biodiesel are there a reduction of thermal efficiency compared with diesel due to lower calorific value. The utilization of heat energy due to methyl ester has a higher molecular weight, the combust totally on diffusion blistering in the Stroke; as a result power reduction in the engine. At the full load condition bordering improvement in the brake thermal efficiency. Nano Rhodium Oxide retaining greater activity and can react with water vapors formed during combustion at high temperature and it makes hydrogen and improves the fuel combustion

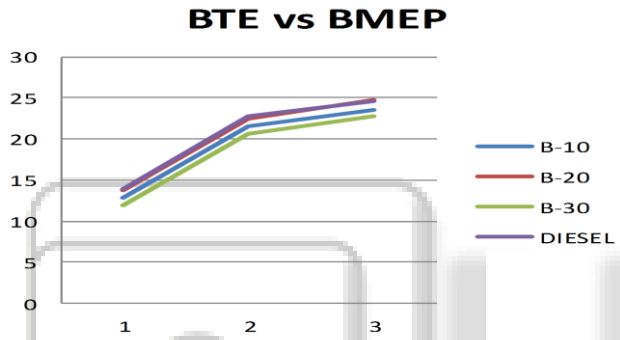

Fig. 9: BMEP vs. BTE

VI. EMISSION CHARACTERISTICS

A. CO vs. BMEP:

The figure 10 shows the difference of CO at engine load conditions for various blends of biodiesel. CO emission is decreasing with the increase in quantity of biodiesel blends. The reason for CO emission is high due to rich combustion. During combustion it formed intermediate product. The exhaust stream is emitted when its development of CO_2 is not completed due to the absence of oxygen. The reduction of Co emission for B-20 biodiesel compare with diesel. The addition of metal oxides in the Nano range, CO emission is reduction effected. There is a reduction of CO emission is 20% at load because metal oxides act as an oxygen buffer and gives surface lattice oxygen.

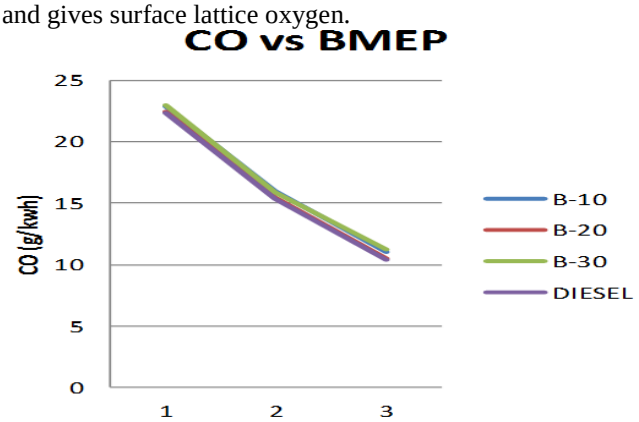

Fig. 10: BMEP vs. CO

B. NO_x vs. BMEP:

The pongamia oil having high percentage of exhaust gas temperature with blends of biodiesel when compared with diesel at full load conditions. The biodiesel has slower burning characters which cause a delay of energy release, as a result higher temperature in the parts of the exhaust and power stroke. The formation of NO_x which cause higher combustion temperature and injection timing & period. The existence of fuel bound oxygen helps better combustion and increase the temperature in cylinder so NO_x emission is increased. In presence of metal oxide is a single active for decomposition of NO_x is reduced. The nano fuel reduces up to 17% of NO_x emission in B-20 of biodiesel. The variables of oxides of nitrogen an BMEP are Shown in the figure 11.

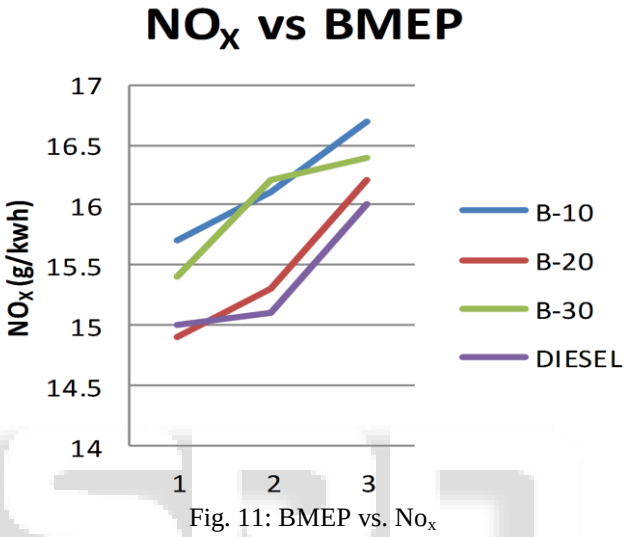

Fig. 11: BMEP vs. No_x

C. HC vs. BMEP

HC emission is an incomplete burning of carbon compound in the blends of biodiesel. Addition of nano particles, it will help to reduce an unburnt hydrocarbons. Nano particles are helping to complete combustion of blends of biodiesel. As a result the emission of HC is reduced at B-20 comparing with diesel fuel. Biodiesel has a higher cetane number as a result HC emission is decreased due to delay of shorter delay. Nano particles is reduces the fuel rich zone and improves the combustion. Fuel additive act as an oxygen buffer and rejects fuel rich zone, which result is a 25 % reduction in HC emission in B-20 Biodiesel compare with neat biodiesel. It is mingling will be better and fuels burn fully. The variation of HC and BMEP are shown in the figure 12

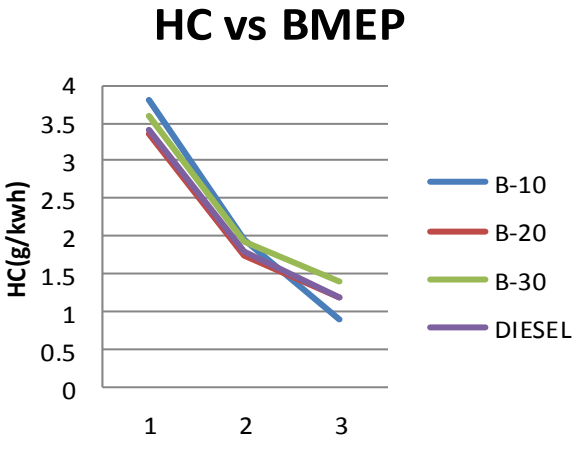

Fig. 12: BMEP Vs. CO

VII. CONCLUSION

The present investigation of blends of biodiesel in the performance and emission characteristics is studied and based on the experimental the following conclusion are, pongamia methyl ester has a lower heating value because of higher energy consumption and lower efficiency. The nano fuel additive helps in the improvement of efficiency compare with diesel. The properties of fuel of B-10 and B-20 are similar to diesel fuel. The without modification of blends of biodiesel are used in CI engine and the performance of the fuel is an improvement and emission characteristics of CI engine is reduced. With the presence of additives in biodiesel is control air quality by reducing harmful emission of diesel fuel. CO emission is up to 20% because metal oxides in biodiesel act as an oxygen buffer and contributes surface lattice oxygen. NO_x emission is increases comparing with diesel and biodiesel blends, the presence of fuel additive was observed 17% reduction of NO_x emission.

REFERENCES

[1] Gaurav Dwivedi M.P. Sharma, "Prospects of biodiesel from Pongamia in India," Renewable and Sustainable Energy Reviews, pp. 114-122, 2014.
[2] Ganesh D, "Effect of Nano-fuel additive on emission reduction in a Biodiesel fuelled CI engine" IEEE, pp. 3453-3459, 2011.
[3] Yanangan, Li Qiao, "Combustion Characteristics of fuel droplets with addition of nano and micron-sized aluminium particles," Combustion and Flame, pp. 1-15, 2010.
[4] Husnawan M, Masjuki H, Mahlia TM I, Mekhilef S, M.G Saifullah, " Use of post flame metal-based and oxygenated additive combination for biodiesel-diesel blends," Journal of Scientific & Industrial Research, vol. 68pp. 1049-1052, 2009.
[5] HimanushuTyagi, Patrick E,Phelan, Ravi prasher, "Increased Hot -plate Ignition Probability for Nanoparticle –Laden Diesel Fuel," Nano Letters, vol. 08, pp. 1410-1416, 2009. 3459
[6] S. Arumugam, G. Sriram, R. Ellappan, "Bio-lubricant-biodiesel combination of rapeseed oil: An experimental investigation on engine oil tribology, performance, and emissions of variable compression ngine" Energy, vol.72, pp.618-627, 2014.
[7] Bawane R.K. et. al (2014) 'Experimental Investigation of Emission Characteristics of Calophyllum Inophyllum Linn (Honne) Oil as Alternative Fuel in CI Engine', International Journal of Scientific & Engineering Research, Volume 5, Issue 6, pg: 627-630.
[8] T. Ganpathy R.P akkhar K.Murugesan, "An Analytical and Experimental Study of performance on Jatropha Biodiesel Engine" Thermal Science, volume . 13, no.3, pp69-82, 2009.
[9] H.M. Dharmadhikari, P. Ravikumar, S. Srinivasa Rao, "Performance and Emissions of CI Engine Using Blends of Biodiesel and Diesel At Different InjectionPressures" International Journal of Applied Research in Mechanical Engineering, VOl. 2, Iss 2, 2012.
[10] H. Raheman, P.C. Jena, S.S. Jadhav, "Performance of a Diesel Engine with Blends of Biodiesel (from a mixture of oils) and High-Speed Diesel.", International Journal of Energy and Environmental Engineering 2013.
[11] A. Haiter Lenin, R. Ravi, K. Thyagarajan, "Performance Characteristics of a Diesel Engine Using Mahua Biodiesel as Alternate Fuel" Iranica Journal of Energy and Environment. Vol. 4, Iss. 2136-141,2013
[12] S.N. Bobade and V.B. Khyade "Preparation of Methyl ester (Biodiesel) from Karanja (Pongamia pinnata) Oil" Research Journal of Chemical Sciences, Vol. 2(8), 43-50, August (2012).

