Effect of Injection Timing and Injector Opening Pressure on The Performance of Diesel Engine Fuelled With Jatropha and Their Blends With Graphene Nanoparticles

Yariswamy M[1], Dr. Hiregoudar Yerranagoudaru[2]
[1, 2]RYMEC BALLARI

Abstract- *Requirement for crude petroleum oil is increasing rapidly with development of world economy. These crude oils are fast depleting in nature and their utilization in diesel engines are detrimental to the environment. Scholars are engrossed in the CI engines for their sound fuel economy with high CR and no throttling losses. Conventional CI engines grieves from higher nitrogen oxides (NOx) and particulate matter (PM) emissions. In this direction use of renewable fuels like biofuels in a diesel engine has been investigated as it has gained prominence over last 20 years, as it is renewable addressing environmental and economic benefits. Scope for improvement in the performance of the existing diesel engines associated with emission reduction with biodiesel as the alternative fuel. Fuel modification plays a prominent role in enhancing engine performance and emission reduction. Recently, Nano-particles as additives in diesel and biodiesel has been the research focus at it improves performance and emission characteristics of the engine. Nano particles with high catalytic effect and high surface area enhance the physicochemical properties of fuel and lower the emission of harmful pollutants as these provide catalytic effect on the combustion of hydrocarbons.*

The project will use advanced experimental techniques to study jatropha biodiesel in modified diesel engine with optimized constraints like injection timing and injector opening pressure. The project also aims to investigate experimentally the demonstration of a future CI fuels when 0powered with jatropha biodiesel and their blends with graphene nanoparticles.

Keywords- Biodiesel, Diesel engine, Emissions, nanoparticles, Graphene, Injection Timing, Injector Opening Pressure.

I. INTRODUCTION

The worldwide concern for pollution, ozone layer depletion and global warming has made it very necessary to reconsider the use of conventional fossil fuels of gasoline, diesel, coal as well. In view of the rapid escalation in energy demand and increasing cost of fossil fuels, it is essential to explore suitable alternative and renewable energy resource for automotive traction and power generation. The existing worldwide search for non-petroleum alternative fuels to IC engines will continue due to existing fossil fuel-based energy reserves being insufficient to meet increasing energy demands of the future. The conventional energy sources are depleting in nature with the existing oil resources anticipated to meet energy demand till 2030 as per world energy outlooks IEA. Energy usage refers to economic growth and societal up liftment [1-2], also GDP and per capita energy consumption is accounted as an in indication of affluence of any country [3-4].

Indian Energy Scenario

Ministry of New and Renewable Energy (MNRE) has been constituted by Government of India to provide necessary guidelines and policies to deal with matters related to new and renewable energy. By 2013, India assumed world's fourth largest oil consumer and this growth in oil demand placed India the fourth largest oil importer since 2011. Indian refineries have shown petroleum products 220.756 MMT during 2013-14 which is higher by 1.39% as compared to the previous year

Parameters Considered for Alternative Fuel Selection

Before utilization of an different fuel in an existing engine the following important parameters should be considered:

- Minimum modifications of existing engine.
- Utilization of existing storage and transportation infrastructure.
- Biodegradable and non-toxic components for safe handling and transportation.

- Capability of being produced from local resources with minimum investment cost.
- Efficient methods for oil extraction method and transesterification to be promoted.

Sl. No.	Non-edible oil	Botanical Name	Potential, tonnes
1	Honge (Karanja)	Pongamia Pinnata	135,000
2	Rice Bran	Orzya sativa	5,25,000
3	Ratanjyot	Jatropha carcus	1,25,000
4	Neem	Azadirachta indica	400,000
5	Kusum	Schleichere oleosa	38,000
6	Pilu	Salvadora oleoides	20,000
7	Tumba	Citrullus collocynthis	25,000
8	Sal	Shorea robusta	1,90,000
9	Mahua	Madhuca indica	2,20,000
10	Mango	Mangifera indica	60,000
11	Phulware	Cheura	9000
12	Kokum	Garcina indica	2500
13	Chullu	Prunus amenieca	1200
14	Simarouba	Simaruba glauca	1000
15	Jojoba	Simmondsia chinesis	10000

Properties of Non-oils available in India

II. FUELS USED IN THE PRESENT WORK

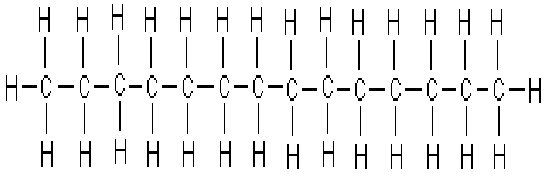
Fuel properties such as physical and chemical properties affect engine performance and hence selecting the right fuel for particular type of engine is essential. Fuel used in an engine must have an ability to result in good combustion with lower exhaust emission levels and satisfy the engine requirements adequately. In this work the engine operated solely with Diesel, JOME and its blends with NPs in single fuel mode as pilot fuels. The data from the experiments were acquired and analysed.

Following fuels were selected for the present study:

Diesel, Biodiesels-Jatropha oil Methyl Ester(JOME), JOME-NPs

Diesel fuel

Diesel is a fraction of petroleum that comes in between kerosene and lubricating oils. Diesel fuel consisting of various types of hydrocarbons derived from refining of crude petroleum. Diesel is distilled at a temperature from 345 to 470°C. The diesel fuel evaporates generally in the temperature of 150-390°C. Properties of diesel fuel are influenced by refining method adopted. Density of diesel fuel varies generally in the range 810 to 860 kg/m^3.



Molecular structure of diesel

Properties of Jatropha oil

This oil is thick, non-drying and is non-edible. Properties of this oil and diesel are given in Table 3.3.Chemical structure, formula and molecular weight are determined (Bangalore test house, Bangaluru, Karnataka, India). Jatropha carcusis a high potential non-edible oil plant and the biodiesel derived from the same was used in the present study. It belongs to the family of Euphorbiaceous. The jatropha seeds usually contain 50-60 % oil..

Jatropha tree

Jatropha seeds

Serial no	Parameters	Jatropha oil	Diesel
1	Kinematic viscosity	44.6	3.2
2	Calorific value, kj/kg	33,900	43500
3	saponification value	208.27	0
4	Density, kg/m3	930	840
5	Acid value (max)	18.01	0.06
6	Moisture (%max)	0.2	24.66
7	Pour point in degree	-2 to -5	1

Biodiesel production

In the present energy scenario, vegetable oils usage for engine applications has become noteworthy. Vegetable oils directly in diesel engines results into operational problems due to their properties and also responsible for such characteristics. In the present work transesterification has been considered because it is more economical than other fuel conversion process

Transesterification process

Transesterification is a method to produce biodiesels from selected vegetable oils. In this method, triglycerides react with ethanol/methanol with catalyst (NaOH, KOH) resulting in a mixture of alkyl esters (known as biodiesel) and glycerol respectively. Transesterification process is pretentious by content of free fatty acid, catalyst type, molar ratio, temperature, and reactants purity. This process reduces free fatty acid (FFA), density, viscosity and improve the oil property as well. In the present work JOME obtained transesterification process. In the transesterification process, 1% NaOH catalyst or KOH (% mass basis) is dissolved in 20% methanol or ethanol (by volume) taken in round bottom flask (2-liter capacity). Then 1.00 litre of jatropha is mixed with mixture of methanol and NaOH solution in round bottom flask then round bottom flask is placed on a magnetic stirrer. Mixture is made hot at 70°C and stirred simultaneously at about 250 rpm.

Jatropha oil methyl ester

JOME was produced using Transesterification process in the process, 1% NaOH catalyst or KOH [% mass basis]is dissolved in 20% methanol or ethanol [by volume] taken in round bottom flask [2-litre capacity].Then 1-litre of jatropha oil is mixed with the mixture of methanol and NaOH solution in the round bottom flask then the round bottom flask is placed on a magnetic stirrer.The mixture is heated up to 70°C and stirred simultaneously at about 250 rpm. This method resulted in higher yield of about 98% with minimal side reactions. The yield of biodiesel (methyl ester) and ethyl ester were 92% and 90% on the basis of refined jatropha oil in the pilot plant scale.

Separation of ester and Glycerin using separating funnel

Materials and Method used for Nano-Jatropha blends Graphene

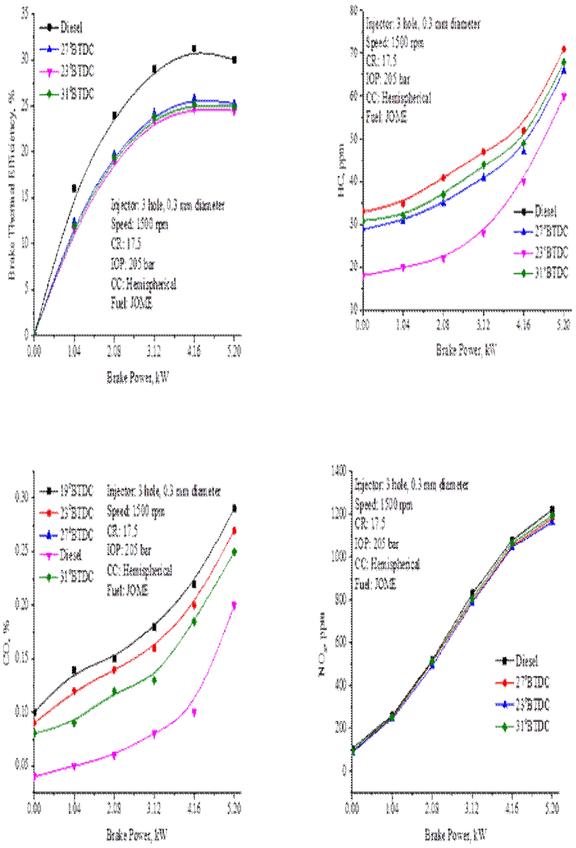
Graphene is a monolayer of carbon atoms, bonded to each other in a structure of honey comb. It is the thinnest material ever discovered with Carbon-Carbon bond length of 0.142 nm and inters planar distance of 0.335 nm. It has a large specific surface area of 2630 m^2/g (theoretical) and the thermal conductivity value of 5000 W/m-K (theoretical) at room temperature.Graphene burns at low temperature of 350°C. Graphene is fully consumed in combustion; contributes to the fuel energy density and no exhaust PM emission

Properties of Graphene

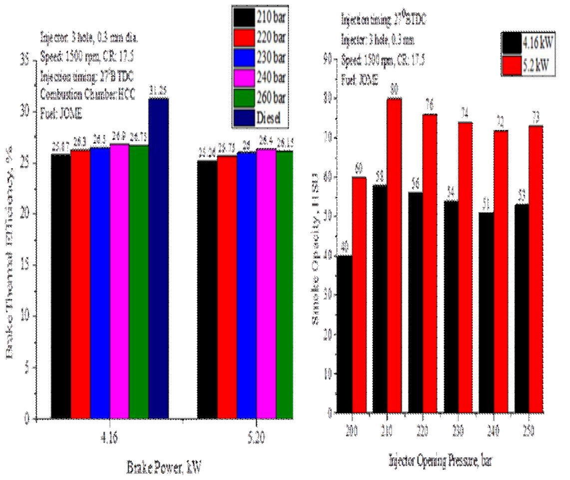
Sl. No.	Parameter	Property
1	Manufacturer	Sigma Aldrich
2	Average Particle Size	22.5 -26 nm
3	Surface area	492 m^2/gm
4	Purity	99.5 %
5	Thermal Conductivity	3000 W/m-K

Effect of Injection Timing on JOME fuelled with diesel engine:

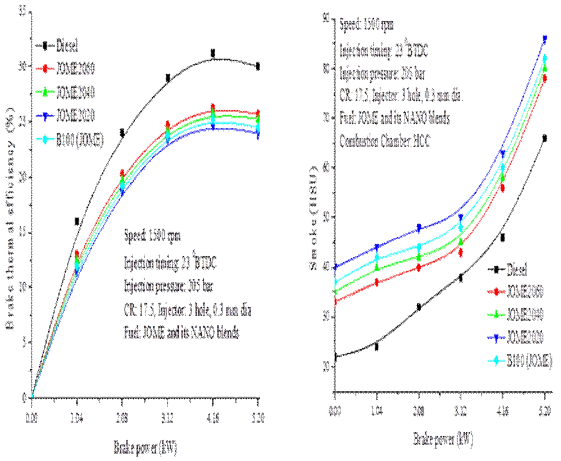
In the first phase of this work, studies on basic performance, emission and combustion characteristics of a single cylinder diesel engine when fueled with diesel, and Jatropha oil methyl ester (JOME) were carried out. At the rated speed of 1500 rev/min, variable load tests were conducted at four injection timings of 23^0, 27^0 and 31^{0}BTDC keeping injection pressure constant at 205 bar. For each load, air flow rate, fuel flow rate, exhaust gas temperature, HC, CO, CO_2, smoke and NO_x emissions were recorded .optimum IT was determined for each of the fuel tested

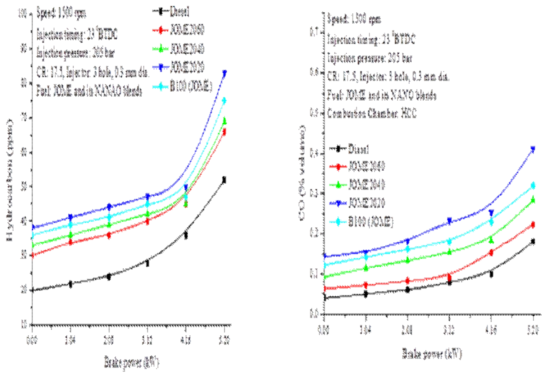


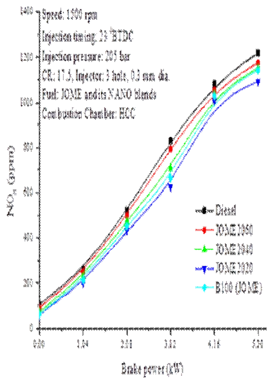
Optimization of Injector Opening Pressure on JOME fuelled Engine : IOP were varied from 205 bar to 260 bar



Effect of Graphene Nanoparticles addition in different levels with Jatropha biodiesel and Diesel blends on performance, combustion and emission characteristics of CI engine







III. CONCLUSIONS

From the tests conducted following conclusions can be drawn:

Effect of the Injector opening pressure and Injection Timing:

- Jatropha biodiesel enhanced demonstration and exhaust emission of a CI engine with modifications in the injection parameters such as ITs and IOP.
- Advancing ITs enhanced BTE, and the emissions of smoke, CO, HC were reduced while NOx enhanced.
- Advancing IT enhanced Peak Pressure and reduced the ID and CD respectively.
- Increasing the injector opening pressure enhanced BTE, and reduced the emissions of smoke, HC, CO while NOx emissions increased.
- Increasing IOP enhanced Peak Pressure and reduced the ID and CD respectively.
- Accordingly, 27°btdc was optimized as the IT while IOP of 240 bar was optimized for improved engine performance when fuelled with Jatropha biodiesel.

Effect of Nano-JOME Biodiesel blends:

- Jatropha with NPs can facilitate performance of CI engine with minor engine modification.
- Stable homogenously Jatropha nano-fuel can be prepared using SDS surfactant.Best performance at JOME2040 has yielded.
- Diesel operation as compared to enhanced BTE by 8.12% along with JOME2040. On 39.58%, 17.42% and14.82% of CO, HC and NOx respectively as it reduces harmful emissions by JOME 2040 as compared to diesel operation.JOME 2040 helped ID, CD and fuel evaporation was decreased.SME2040 were be observed with greater PP.

REFERENCES

[1] Agarwal A.K., Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines, Progress in Energy and Combustion Science, Vol.33, 2007, pp. 233–271.

[2] Murugesan A., Umarani C., Subramanian R., Nedunchezhian N, Bio-diesel as an alternative fuel for diesel engines-A review, Renewable and Sustainable Energy Reviews, Vol. 13, Issue 3, 2009, pp. 653-662.

[3] Kjarstad J., Johnsson F., Resources and future supply of oil, Energy Policy, Vol. 37, 2010, pp. 441–64.

[4] Planning Commission of India, Report of the Expert Committee on Integrated Energy policy, 2006.

[5] Anne-Sophie Corbeau, Natural Gas Vehicles, Working Paper, IEA 2010, Paris, 2010.

[6] BP Energy Outlook 2035, January 2014.

[7] International conference on bio-fuels, vision to reality, Energy Fuel Users Journal, January–March 2006, pp.6–8.

[8] Haldar S. K., Ghosh B.B., Nag A., Studies on the comparison of performance and emission characteristics of a diesel engine using three degummed Non-Edible Vegetable oils, Biomass and Bioenergy, Vol. 33, 2009, pp. 1013-1018.

[9] Tint Tint Kywe, Mya Mya Oo, Production of Biodiesel from Jatropha Oil (Jatropha curcas) in Pilot Plant, World Academy of Science, Engineering and Technology, Vol.6, 2009, pp.477- 483.

[10] Satoshi Horikoshi, Nick Serpone. Introduction to Nanoparticles. Microwaves in Nanoparticle Synthesis, First Edition: pp 1-24 © Wiley-VCH Verlag GmbH & Co. KGaA 2013.