

# Experimental Investigation of Emission Analysis of Diesel Engine Fueled with Pongamia Oil Blends and Petroleum Diesel

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**Abstract:** Under Ideal stoichiometric condition, Carbon dioxide [CO<sub>2</sub>] and water [H<sub>2</sub>O] ought to be the only emissions from the Diesel engine. Transesterification is a chemical process implement to convert raw vegetable oils to biodiesel on usual practice. In the present analysis an effort has made to induce the properties of petroleum diesel to the raw vegetable oil upon mixing high volatile solvent such as petrol. The prepared biodiesel upon charging to C I engine, emission characteristics were measured and compared with the conventional emission of C I engine when it was charge with petroleum Diesel. By considering the due effect of viscosity, Calorific value and Flash point temperature densities the corrective measures have taken to bring the value closer to Diesel. To reduce the pollution level within the acceptable range there is a need for alternative fuel which satisfy the criteria of economical and environment feasible.

**Keywords:** Bio fuels, Carbon monoxide [CO], Exhaust emissions, Hydrocarbons [HC].

## I. INTRODUCTION

In the present trend of energy conversion and energy transformations, the more emphasize is given to the methods which have least adverse impact on the atmospheric air. In the automotive industries engine driven by the fossil fuels are the major cause for the air pollution. In order to reduce the pollutant level in the atmosphere air and to employ the applicability of cultivated vegetable seed oil in engine as a means of power generation with the suitable energy conversion mechanism. Bio fuels play its eminent role. The emanate features of bio fuels depends on several factors to be manipulate such as to be manipulate to reduce the viscosity, reduce flash point

temperature, induce desirable level of calorific value, retain its flow ability etc. After the thorough analysis of various vegetable oil to check the suitability in I-C engine. Many researchers come up with an unique sources for the preparation of bio diesel i.e. Pongamia Pinnata seed oil gains the enough applicability to fulfill the need of engine fuel.

## II. EXPERIMENTAL SETUP USED FOR TESTING

In the present work the biofuel has prepared from Pongamia pinnata oil [refine] as base oil and petrol as an additive with an appropriate proportions. Before testing the prepared sample, the required properties were measured at various conditions, based on which an appropriate mixture has selected to run a C I engine for further analysis.



Fig. 1: The Engine Setup with an Alternator and Circuits (Courtesy: HKBKCE, EC Lab)



Fig. 2: Engine and Alternator (Courtesy: HKBKCE, EC Lab)

A. Specifications of Engine Setup Used to Determine Performance Parameter

Table I below gives the specification of the Engine setup as shown in Fig. 2.

TABLE I

Model	AKV-1
Power	5HP
Cooling	Water Cooled
No. of cylinder	One
Type	Vertical, 4-stroke, Compression ignition
Rpm	1500
Rotation	Clockwise handle stroke
Starting	Handle start with cranking
Bore (mm)	80
Stroke length (mm)	80

III. EMISSION TESTING

The emission testing of an oil sample of Pongamia 85% + petrol 15% and a diesel sample is carried out using GAS ANALYSER which is a 5-gas analyzer designed for testing contents of Carbon Monoxide, Carbon dioxide, Hydrocarbons, Oxygen and Oxides of Nitrogen in an engine exhaust. Carbon Monoxide, Carbon dioxide and Hydrocarbons are measured by NDIR technology and Oxygen percentage and Oxides of Nitrogen contents by electrochemical sensors. The setup consists of many measuring control characteristics to prevent faulty measurements. The report can be obtain with the help of built-in dot matrix printer within the setup.



Fig. 3: Gas Analyzer

IV. ENGINE EXHAUST ANALYSIS OF PETROLEUM DIESEL AND OIL SAMPLES AT FULL LOAD CONDITION

The biofuel prepared by blending Pongamia pinnata oil and petrol has tested in 5HP C I Engine at full load conditions.

Table II gives the detail information obtained from the engine setup for the two different samples at two different load conditions.

TABLE II: VOLTAGE AND CURRENT FOR TWO DIFFERENT LOADS

Type of Fuel	Loads in Watts	Time to Run Down 10 cc of Fuel (t) in Sec	Voltage in (V)	Current in (Amps)
Diesel	1000	42	230	4
	2000	34	240	7.6
Pongamia oil (85%) + Petrol (15%)	1000	40	230	4
	2000	31	240	7.2

The exhaust emitted by C I Engine when it was fuelled with prepared sample separately and with petroleum Diesel separately at full load condition, was analyzed with the help of Gas analyzer. The results obtained are listed in the Table III.

TABLE III: EMISSION VALUES FOR DIESEL AND BIODIESEL SAMPLE

Test for Exhaust	Readings for Diesel Sample	Readings for Pongamia Oil Blends
Hydrocarbons	4PPM	-
CO <sub>2</sub>	2.48%	2.11%
NO <sub>x</sub>	497PPM	271PPM
O <sub>2</sub>	17.78%	18.23%
SO <sub>2</sub>	-	4PPM
CO	270PPM	430PPM

For the sake of clarity the detailed graphs are plotted according to the test result obtained from emission test of petroleum diesel and pongamia oil blend and compared below.

Emission Measurement

1. Automotive exhaust monitor (Indus smoke meter model OMS103)

- Range-0 to 100% opacity in HSU; 0 to ∞ in k (1/m)
- Resolution-0.1% in HSU, 0.01 (1/m) in k
- 2. Automotive exhaust monitor Indus five gas Analyzer model PEA-205
- Range- Carbon monoxide: 0 to 15%, Hydrocarbons: 0 to 30000 PPM as hexane,
- Oxygen: 0 to 25%,
- Carbon dioxide: 0 to 20% and Oxides of nitrogen: 0 to 5000 PPM,
- Data resolution-Carbon monoxide: 0.001%,
- Oxygen and Carbon dioxide: 0.01%,
- Hydrocarbons and Oxides of Nitrogen: 1 PPM

*A. Variation of Carbon Dioxide between Petroleum Diesel and Fuel Sample*

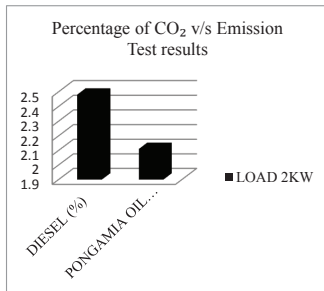


Fig. 4: Percentage Variation of CO<sub>2</sub> in Petroleum Diesel and Fuel Sample

Fig. 4 shows the variation of carbon dioxide emission with different blends at full load. Carbon dioxide is a byproduct of efficient and complete combustion. Carbon dioxide levels are affected by air / fuel ratio, spark timing and any other factor which affect the combustion efficiency. At full load pongamia oil blends gives less carbon dioxide as compared to the diesel. The carbon dioxide increases with the increase in load due to higher fuel entry as the load increases. Pongamia oil contains low carbon content as compared to diesel due to this carbon dioxide emission are also low.

*B. Variation of Carbon Monoxide between Petroleum Diesel and Fuel Sample*

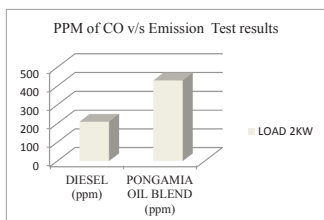


Fig. 5: PPM Variation of CO in Petroleum Diesel and Fuel Sample

Fig. 5 shows the variation of carbon monoxide with different sample that is for diesel and pongamia oil blend. Pongamia oil blend gives higher carbon monoxide as compared to the diesel fuel at full load condition due to the incomplete combustion.

The content of oxygen in fuel sample undergoes complete combustion and supplies the necessary oxygen to convert Carbon monoxide to Carbon dioxide. At 50% load condition the content of CO in engine emission is almost negligible.

*C. Variation of Sulphur Contents between Petroleum Diesel and Fuel Sample*

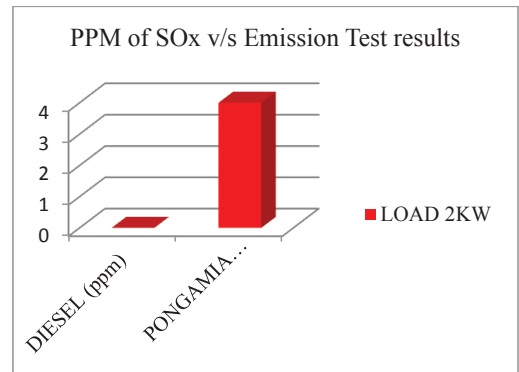


Fig. 6: PPM Variation of SO<sub>x</sub> in Petroleum Diesel and Fuel Sample

Fig. 6 shows the variation of sulphur content in the engine exhaust when the fuel used was diesel and pongamia oil blend with full load condition. From the above graph it can be observed that the content of sulphur in the engine exhaust is least and negligible when it was running with diesel sample, whereas the Sulphur content in the exhaust is comparatively more when the engine was running with pongamia oil blend as fuel.

*D. Variation of Oxides of Nitrogen between Petroleum Diesel and Fuel Sample*

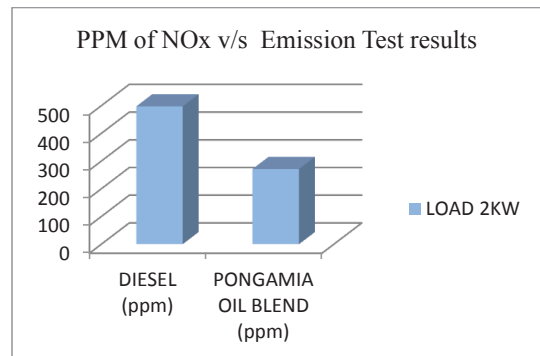


Fig. 7: PPM Variation of NO<sub>x</sub> in Petroleum Diesel and Fuel Sample

Fig. 7 shows the variation of nitrogen dioxide emission with different blends at different load about 90% nitrogen in the exhaust is in the form of nitric oxide. The three important factor which support the formation of nitric oxide such as oxygen concentration, combustion temperature and retention time. These three conditions are attained in pongamia blends combustion very rapidly as compared to diesel. More and superior emission quality of pongamia oil blends can be observed, since its emission is lesser than the nitrogen dioxide diesel emission.

*E. Variation of Oxygen Percentage between Petroleum Diesel and Fuel Sample*

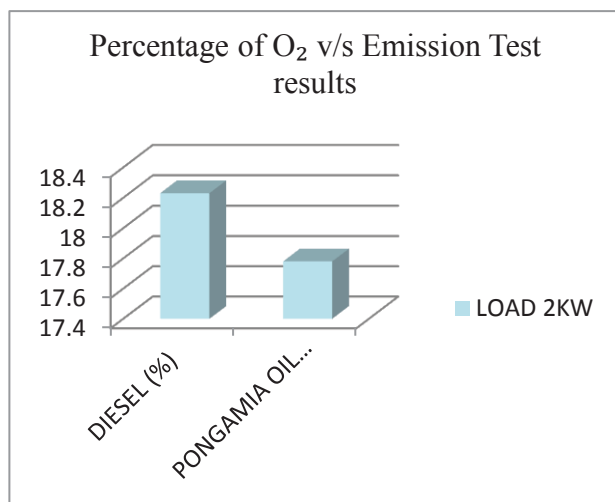


Fig. 8: Percentage Variation of Oxygen between Petroleum Diesel and Fuel Sample

Fig. 8 shows the variation of oxygen percentage in engine exhaust when it was run by diesel and pongamia blend fuel sample with full load condition. From Fig. 8 it is observed that the percentage of oxygen in engine exhaust is high when fuel used was diesel and the percentage of oxygen in engine exhaust was comparatively low when fuel used was pongamia oil blend sample.

*F. Variation of Hydrocarbons between Petroleum Diesel and Fuel Sample*

Fig. 9 shows the variation of hydro carbon emission with pongamia oil blend and diesel at full load condition. Pongamia oil blend gives lower hydro carbon emission as compared to the diesel. The availability of excess oxygen content in the pongamia oil blend as compared to the diesel facilitates to convert hydrocarbon to H<sub>2</sub>O and CO<sub>2</sub>. From the above graph it can be observed that hydro carbon emission is zero compared to diesel.

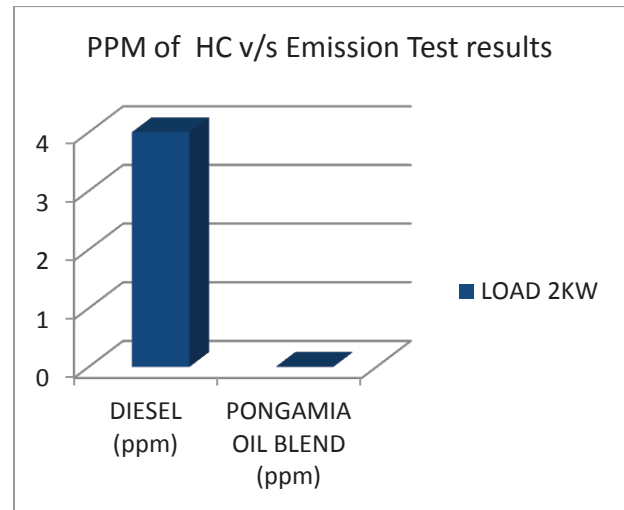


Fig. 9: PPM Variation of between Petroleum Diesel and Fuel Sample

V. RESULTS AND DISCUSSIONS

In the current investigation it was found that the pongamia oil blend of proportion 85% + petrol 15% exhibited most desirable and superior quality to that of diesel fuel. When compared to the other proportion of pongamia oil blends and a sample of 100% pongamia oil itself. The pongamia oil 85% + petrol 15% and the petroleum diesel tested result are listed below.

TABLE IV: FUEL PROPERTIES SHOW THE COMPARISON OF PONGAMIA OIL BLEND WITH PETROLEUM DIESEL

Test	For Diesel	For Pongamia oil 85%+ Petrol 15%
Kinematic viscosity at 50°C	0.28cSt	9.54cSt
Density at 50°C	682kg/m <sup>3</sup>	778kg/m <sup>3</sup>
Dynamic viscosity at 50°C	0.000236N-s/m <sup>2</sup>	0.00628N-s/m <sup>2</sup>
Flash point temperature	53°C	35°C
Calorific value	41800kJ/kg	39458kJ/kg

The selected oil blend was used to run the engine and it was observed that the 5HP kirloskar engine was running smoothly with the same full throttle opening similar to that of diesel without any disturbance. The engine was heated by starting the engine with the same full throttle opening similar to that of diesel without any disturbance. The engine was heated by running the engine with diesel for about half an hour, since the sample shows much reduced viscosity and density at higher temperature. The same sample is used to run the engine to

determine the performance parameter at varying load of 50% and full load condition. By testing it was found that the sample exhibits much comparable results when compared to the petroleum diesel.

## VI. CONCLUSION

In the present experimentation attempt has made to prepare a fuel substitute for petroleum diesel in diesel engine. In usual practice in order to prepare biodiesel from any vegetable oil it has to be subjected to transesterification process. Transesterification includes vegetable oil or creature fats being responded with short chain alcohols, for example, methanol or ethanol, in nearness of impetus. In the transesterification procedure the additional liquor is deprotonated with a base to make it a more grounded nucleophile.

Amid response triglycerides are responded with a liquor, for example, ethanol to give ethyl esters of unsaturated fats and glycerol.

During transesterification the viscosity of vegetable oil falls to the acceptable range and the flash point temperature also falls to the required level. In the present experimentation the above deciding parameters such as kinematic viscosity, flash point temperature and density of the vegetable oil lower to vegetable oil lower to the required range by blending the petrol in appropriate proportions.

Based on the engine performance and emission characteristics, one can conclude that the prepared sample consist of pongamia oil [85%] + petrol [15%] shows more feasible results. At the full load condition the engine behaves normal working with prepared sample similar to the engine behavior when it is fuelled with petroleum diesel. The results obtained from the emission testing conducted for the above setup when an engine is fuelled with prepared sample falls well within the acceptable range.

With the thorough observation of the above graph one can conclude the feasibility of biofuel sample as compared to the fossil fuel.

## REFERENCE

- [1] K. P. Barua, "Biodiesel from seeds of *Jatropha* found in Assam," *International Journal of Energy, Information and Communications*, vol. 2, no. 1, pp. 53-65, February 2011.
- [2] P. Nakpong, and S. Wootthikanokkhan, "Optimization of biodiesel production from *Jatropha curcas* L. oil via alkali-catalyzed methanolysis," *Journal of Sustainable Energy and Environment*, vol. 1, pp. 105-109, 2010.
- [3] B. V. Babu, K. R. Suresh, and V. Yathish, "Effect of dairy scum oil methyl Ester on a DI diesel engine performance and emission," *International Journal on Theoretical and Applied Research in Mechanical Engineering*, vol. 1, no. 1, 2012.
- [4] V. Chalatlou, M. M. Roy, A. Dutta, and S. Kumar, "Jatropha oil production and an experimental investigation of its use as an alternative fuel in a DI diesel engine," *Journal of Petroleum Technology and Alternative Fuels*, vol. 2, no. 5, pp. 76-85, May 2011.
- [5] S. K. Sinha, V. Vibhanshu, N. Kumar, and Amardeep, "Experimental investigation of performance and emission characteristics of blends of *Jatropha* oil methyl ester and ethanol in light duty diesel vehicle," *International Journal of Engineering Research and Applications*, vol. 4, no. 2 (version 1), pp. 374-383, February 2014.
- [6] R. V. Koti, S. B. Prakash, K. Kiran, and T. Ravikumar, "An investigation on the performance and emission characteristics of a direct injection diesel engine using safflower oil and milk scum oil as a biodiesel," *International Refereed Journal of Engineering and Science*, vol. 3, no. 4, pp. 19-27, April 2014.
- [7] K. V. Yatish, R. Suresh, and E. Amruth, "Optimization of biodiesel production from mixed oil (*Karanja* and Dairy waste Scum oil) using homogeneous catalyst," *IOSR Journal of Applied Chemistry*, vol. 3, no. 6, pp. 9-15, Jan.-Feb. 2013.
- [8] A. Shirneshan, M. Almassi, B. Ghobadian, A. M. Borghei, and G. Najafi, "Effects of biodiesel and engine load on some emission characteristics of a direct injection diesel engine," *Current World Environment*, vol. 7, no. 2, pp. 207-212, 2012.
- [9] D. K. Ramesha, H. N. Vidhyasagar, and M. Kishore, "Diesel engine exhaust emission characteristics of CI engine using non-edible plant oil as fuel," *International Journal of Emerging Trends in Engineering and Development*, vol. 3, no. 2, pp. 293-298, April 2012.
- [10] V. Sisarwal, and A. C. Tiwari, "Experimental investigation of effect of straight vegetable oil fuel on engine performance parameters," *International Journal of Engineering Research and Applications*, vol. 3, no. 1, pp. 2091-2094, Jan.-Feb. 2013.
- [11] S. M. A. Rahman, H. H. Masjuki, M. A. Kalam, M. J. Abedin, A. Sanjid, and S. Imtenan, "Effect of idling on fuel consumption and emissions of a diesel engine fueled by *Jatropha* biodiesel blends," *Journal of Cleaner Production*, vol. 69, pp. 208-215, April 2014.
- [12] Y. Pasha, U. Shrinivasa, and D. R. Swamy, "Experimental investigation of a mixture of a non-edible plant oil and an additive as a straight fuel in CI engine of an irrigation pump set," *IPASJ International Journal of Mechanical Engineering*, vol. 2, no. 7, pp. 27-33, July 2014.

- [13] N. P. Rathod, and S. M. Lawankar, "Comparative study on use of biodiesel (Methyl Ester Kusum Oil) and its blends in direct injection CI engine - A review," *International Journal of Emerging Technology and Advanced Engineering*, vol. 3, no. 9, September 2013.
- [14] S. V. Prakash, *et al.*, "Biomethanation plant for vegetable waste and utilization of biogas slurry," *International Journal of Research in Advent Technology*, vol. 2, no. 8, August 2014.
- [15] S. Ghosh, and D. Dutta, "Performance and exhaust emission analysis of direct injection diesel engine using pongamia oil," *International Journal of Emerging Technology and Advanced Engineering*, vol. 2, no. 12, pp. 341-346, 2012.