

Performance And Emission Characteristics of Bio Diesel from Pongamia Oil, Methanol, Koh and Its Effects on Ci Engine

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ABSTRACT: An ever increasing demand of fuels has been a challenge for today's scientific workers. The fossil fuel resources are reducing day by day. So we need environmental viable fuel of biodiesel seem to be a solution for future. It is an environmental viable fuel. Several researchers have made systematic efforts to use plant oil and their biodiesel as a fuel in compression ignition engines. There are various types of raw material like Pongamia Pinnata, Neem seeds, Cashew nut, Waste vegetables, Cotton seed, etc. A non-edible oil seeds and various vegetable oils including palm oil, soybean oil, sunflower oil, rapeseed oil and canola oil have been used to produce biodiesel fuel and lubricants. Out of these Pongamia pinnata can be a definite source of raw material due to its easy availability in wild. Pongamia pinnata is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. An experimental analysis has been carried out to evaluate the performance and emission characteristics of a compression ignition engine fuelled with dissimilar compositions of Pongamia pinnata biodiesel and its blend at 25%, 50%, 75% and 100% with mineral diesel. HC, CO, CO₂ and smoke were measured.

KEYWORDS: Pongamia Pinnata, Bio-Diesel, AVL Di Gas Analyzer, Kirlosker Engine, Dynamometer, Performance and Emission

I. INTRODUCTION

Biodiesel can be produced from a wide variety of plant oils, both edible and non-edible biodiesel in most of the developed countries are being produced from sunflower, peanut, palm and several other feed stocks which are essentially edible in Indian context. Therefore, in the developing countries such as India, it is desirable to produce biodiesel from the non-edible oils which can be extensively grown in the waste lands of the country. The economic feasibility of biodiesel depends on the price of crude petroleum and the cost of transporting diesel over long distances to remote areas. It is a fact that the cost of diesel will increase in future owing to increase in its demand and limited supply. A great deal of research and development on internal combustion engines has taken place not only in the design area but also in finding an appropriate fuel. Many researchers have concluded that biodiesel holds promise as an alternative fuel for diesel engines, since its properties are very close to diesel fuel. The fuel properties of biodiesel such as cetane number, heat of combustion, gravity, and viscosity influence the combustion and so the engine performance and emission.

Biodiesel is an alternative fuel formulated exclusively for diesel engines. It is made from vegetable oil or animal fats or it is the name for a variety of ester based fuels generally defined as the monoalkyl esters made from vegetable oils through simple transesterification process. It is recommended for use as a substitute for petroleum based diesel mainly because biodiesel is a renewable, domestic resource with an environmentally friendly emission profile and is readily biodegradable. Biodiesel is nontoxic, biodegradable. It reduces the emission of harmful pollutants from diesel engines but emissions of nitrogen oxides are increased. Biodiesel has a high cetane number. The high cetane

numbers of biodiesel contribute to easy cold starting and low idle noise. The use of biodiesel can extend the life of diesel engines because it is more lubricating and furthermore, power output are relatively unaffected by biodiesel.

Pongamia pinnata is a deciduous, salt tolerant, drought resistant nitrogen fixing leguminous tree and their seeds are well known for extraction of non-edible oil. In the present study, the crude oil extracted from *Pongamia pinnata* seed was used to synthesize biodiesel (fatty acid methyl esters) by transesterification with methanol in the presence of two different base catalysts viz. NaOH and KOH at a predetermined optimum temperature of 60°C, stirring speed of 300 rpm for 45 minutes. A percentage conversion of 68% and 73% respectively was achieved by NaOH and KOH catalyzed transesterification reaction. Further, fuel properties of the transesterified oil (biodiesel) obtained using the two catalysts were compared with crude *Pongamia* oil and a biodiesel blend (B20). Fuel properties taken into consideration were density, viscosity and flash point [1].

In this work reaction parameters namely 1) temperature, 2) time, 3) NaOH concentration and 4) methanol/oil ratio in biodiesel production by two step acid/base catalysed trans-esterification of a non-edible vegetable oil from *Pongamia pinnata* has been optimized by 2⁴ central composite design in order to increase diesel yield and reduce reaction time and temperature. Biodiesel yield and composition was confirmed with HPTLC and GC-MS analysis. The optimal conditions were found to be: 1.44 hours reaction time, 65°C reaction temperature, 0.80 wt % NaOH and 7.4:1 methanol to oil ratio. The optimum yield was observed to be 98.84% with the optimal conditions of experiment [2]. Biodiesel was prepared from the non-edible oil of *Karanja* by transesterification of the crude oil with methanol in the presence of NaOH as catalyst. A maximum conversion of 92% (oil to ester) was achieved at 600c. Important fuel properties of methyl esters of biodiesel produced from *karanja* oil like viscosity, flash point, fire point, calorific value etc., was found out and compared to the properties of Indian standard biodiesel [3].

Continually mounting utilization of fossil fuel and petroleum commodities has been a matter of great apprehension for developing countries like India. Augment in inflation, pollution and associated health hazards, global warming, energy security and exhaustion of fossil fuel have propelled alternative energy. An experimental analysis has been carried out to evaluate the performance and emission characteristics of a compression ignition engine fuelled with dissimilar compositions of *karanja* biodiesel and its blend at 5%, 10%, 20%, 25%, 50%, 75% and 100% with mineral diesel. HC, CO, CO₂ and smoke were measured, found lower with *karanja* biodiesel fuel. However, NO_x emissions of *karanja* biodiesel and its blend were higher than diesel. The combustion analysis was done using peak cylinder pressure and heat release rate with respect to crank angle. The peak cylinder pressure and heat release rate was lower for *karanja* biodiesel. Results confirm that the performance of the engine fuelled with *karanja* biodiesel and its blends with diesel fuel is by and large comparable with pure diesel [4]

Self reliance in energy is vital for overall economic development of our country. The need to search for alternative sources of energy which are renewable, safe and non- polluting assumes top priority in view of the uncertain supplies and frequent price hikes of fossil fuels in the international market. Biodiesel (fatty acid methyl ester) which is derived from triglycerides by transesterification, has attracted considerable attention during the past decade as a renewable, biodegradable and nontoxic fuel. Several processes of biodiesel fuel production have been developed, among which transesterification using alkali as a catalyst gives high level of conversion of triglycerides to their corresponding methyl ester in a short duration. This process has therefore been widely utilized for biodiesel fuel production in number of countries. In India, there are many trees bearing oil like *ratanjot* (*jatropha curcus*), *mahua* (*madhuca indica*), *pilu* (*salvodara oleoids*), *nahor* (*mesua ferralina*), *kokam* (*garcinia indica*), *rubber seed* (*hevea brasiliensis*) and *karanja* (*pongamia pinnata*) etc. Among these species, which can yield oil as a source of energy in the form of biodiesel, *Pongamia pinnata* has been found to be one of the most suitable species due to its various favorable attributes like its hardy nature, high oil recovery and quality of oil, etc. An acid value of this oil is high, so that we have to reduce it by the process of esterification followed by transesterification. The methyl ester produced by this way gives the good result. The present study deals with transesterification of *karanja* oil which gives 907ml of *karanja* oil methyl ester (KOME) and 109ml of glycerol using methanol (13%) and sodium hydroxide as a catalyst (1%). The properties like density, viscosity, flash point, cloud point and pour point have been determined as per ASTM standards for accessing the fuel quality of KOME [5].

Pongamia pinnata is a medium-sized glabrous and adaptable tree for tropical and sub-tropical regions which requires excellent drainage and a sunny location. It grows easily from seed. Historically, this plant has long been used in India and neighboring regions as a source of traditional medicines, animal fodder, green manure, timber, fish poison and fuel. Extract of the plant possess significant anti-diarrheal, anti-fungal, anti-plasmodia, anti-ulcerogenic, anti-

inflammatory and analgesic activities. Its oil is a source of biodiesel. It has also alternative source of energy, which is renewable, safe and non-pollutant. This article briefly reviews the botany, distribution, ecology, uses of the plant and as a source of biodiesel. This is an attempt to compile and document information on different aspect of Pongamia pinnata and its potential use as a source of biodiesel [6].

Pongamia Pinnata trees are normally planted along the highways, roads, canals to stop soil erosion. Billions of trees exist all over India. If the seeds fallen along road side are collected, and oil is extracted at village level expellers, few million tons of oil will be available for Lighting the Lamps in rural area. It is the best substitute for Kerosene. Since these are spread over a large area, collection of seeds for Biodiesel manufacture is not viable. (A compact plantation can support a Biodiesel plant. The seedlings of Pongamia can survive in 1.5 meters deep water submergence / inundation for five to six months duration at a stretch. There are nearly 30,000 square km of water reservoirs in India. This tree can be cultivated in our water storage reservoirs up to 1.5 meters depth and reap additional economic value from unused reservoir lands. The estimated annual production of oil from its seeds is about 50,000 t. The oil has not yet found any significant commercial application. But due to increase in awareness and growth in research in this area the Pongamia it can be developed as the alternative source of fuel by replacing diesel. In the present study attempt has been made to study the scope of Pongamia in India [7].

Studies were carried out on transesterification of Karanja oil with methanol for the production of biodiesel. The reaction parameters such as catalyst concentration, alcohol/oil molar ratio, temperature, and rate of mixing were optimized for production of Karanja oil methyl ester (KOME). The fatty acid methyl esters content in the reaction mixture were quantized by HPLC and ¹H NMR method. The yield of methyl esters from Karanja oil under the optimal condition was 97–98% [8].

II. EXPERIMENTAL PROCEDURE

In this paper pongamia oil is raw oil. Take one liter of pongamia oil; the oil was heated in temperature 65⁰C to 70⁰C in magnetic stirrer. Then take methanol 200ml and potassium hydroxide 15 grams both are mixed to make a solution. After the raw oil was reached the temperature 70⁰C, then the methanol and potassium hydroxide solution was mixed in the oil. The raw oil and solution was heat with half an hour, finally biodiesel was produced. The bio diesel was transferred to separating funnel. The funnel was fixed in the clam table, it is allowed to few hours for settling down. At this stage two major products are obtained that are glycerin and biodiesel.



Fig (1) Crude Pongamia Oil



Fig (2) Magnetic Stirrer of Pongamia Oil



Fig (3) Esterification Process



Fig (4) Pure Bio Diesel base from Pongamia Oil

A single cylinder constant speed diesel engine has been selected to conduct experiments and studies the performance. The engine is connected with a dynamometer. The voltage, current and speed were taken using a voltmeter, an ammeter and rpm meter respectively. diesel engine selected for the experimentation is the made of the kirloskar oil engines limited, india. It is a single cylinder, 4-strokes, 1500 rpm constant speed diesel engine of 4.4 HP rated power.

The kirloskar engine is used extensively in agriculture, pump sets, farm machinery and industrial sectors. The engine with stand high pressure encountered during test because of its rugged construction. The injection timing recommended by the manufactural was 27 BTDC. The governor used to maintain constant speed under varying load conditions which control the fuel flow as load changes. The engine as open combustion chambers with over head valves operated through push rods. A provision was made in the cylinder head surface to mount a piezo electric pressure transducer for measuring the cylinder pressure.



Fig (5) Kirloskar Engine

The engine was set to run at constant speed of 1500 rpm. The load of the engine was obtained from load cell reading. The speed of the engine was monitored using sensor along with digital speed indicator. The fuel was supplied to the engine from the diesel tank and burette was placed in the panel board. When the fuel cock was closed the fuel to the engine will flow from the burette the fuel flow rates were obtained noting the time taken for 10cc for fuel consumption. In this study hydrocarbon (HC), Carbon monoxide (CO), nitrogen oxides (NO_x) and smoke emission from the exhaust gas of the test engine were measured. Exhaust gas was sample from exhaust pipe o the test engine

The HC, CO and NO_x emission from the test engine were measured by a AVL Di GAS ANALYZER. It is based on non-dispersive infrared rays technique to measure the pollutants. The analyzer is allowed to warm up for few hours and then checked for the leak test. Before starting the analyzer ensure the absence of water droplets in the tubes of exhaust probe. Also the smoke emission from the test engine was measured in this study. In order to measure smoke emission, an opacity (AVL make) type smoke meter was used.



Fig (6) AVL Di GAS ANALYZER(Five Gas Analyser)

III. RESULTS AND DISCUSSION

The performance and emission of internal combustion engine was tested by various load conditions such as 33.35 N, 67.68 N, 101.04 N, 135.37 N, 169.71 N and various ratio mixtures of diesel and biodiesel. Then tabulate the readings and calculate the various powers and efficiencies. The below tabulation B25 contains the mixture of 25% of bio diesel and 75% of diesel. The tabulation B50 contains the mixture of 50% of bio diesel and 50% of diesel. The tabulation B75 contains the mixture of 75% of bio diesel and 25% of diesel. The tabulation B100 contains the mixture of 100% of pure bio diesel without any other chemical proportion.

Table (1) B25

S. No	Fuel Consumption	Fuel Power	Brake Power	Indicated Power	Brake Thermal Efficiency	Indicated Thermal Efficiency	Mechanical Efficiency	Indicated Specific Fuel Consumption	Brake Specific Fuel Consumption
	$\times 10^{-4}$ Kg/sec	KW	KW	KW	%	%	%	$\times 10^{-5}$ Kg/kw.sec	$\times 10^{-4}$ Kg/kw.sec
1	1.8	7.92	1.02	5.2	12.88	65.66	19.62	3.46	1.76
2	2.5	11	2.07	5.2	18.82	47.27	39.81	4.81	1.21
3	3	13.2	3.09	5.2	23.41	39.39	59.42	5.77	0.97
4	3.4	14.96	4.14	5.2	27.67	34.76	79.62	6.54	0.82
5	4.01	17.64	5.19	5.2	29.42	29.48	99.81	7.71	0.77

TABLE (2) B50

S. No	Fuel Consumption	Fuel Power	Brake Power	Indicated Power	Brake Thermal Efficiency	Indicated Thermal Efficiency	Mechanical Efficiency	Indicated Specific Fuel Consumption	Brake Specific Fuel Consumption
	$\times 10^{-4}$ Kg/sec	KW	KW	KW	%	%	%	$\times 10^{-5}$ Kg/kw.sec	$\times 10^{-4}$ Kg/kw.sec
1	1.89	8.32	1.02	5.2	12.26	62.53	19.62	3.63	1.85
2	2.19	9.64	2.07	5.2	21.48	53.96	39.81	4.21	1.05
3	2.70	11.88	3.09	5.2	26.01	43.77	59.42	5.19	0.87
4	3.66	16.10	4.14	5.2	25.71	32.29	79.62	7.04	0.88
5	4.09	17.99	5.19	5.2	28.83	28.89	99.81	7.87	0.78

TABLE (3) B75

S. No	Fuel Consumption	Fuel Power	Brake Power	Indicated Power	Brake Thermal Efficiency	Indicated Thermal Efficiency	Mechanical Efficiency	Indicated Specific Fuel Consumption	Brake Specific Fuel Consumption
	$\times 10^{-4}$ Kg/sec	KW	KW	KW	%	%	%	$\times 10^{-5}$ Kg/kw.sec	$\times 10^{-4}$ Kg/kw.sec
1	1.89	8.32	1.02	5.2	12.26	62.53	19.62	3.63	1.85
2	2.62	11.53	2.07	5.2	17.95	45.10	39.81	5.03	1.26
3	3.81	16.76	3.09	5.2	18.43	31.01	59.42	7.32	1.23
4	4.18	18.39	4.14	5.2	22.50	28.27	79.62	8.03	1.01
5	4.14	19.40	5.19	5.2	26.74	26.79	99.81	8.48	0.85

TABLE (4) B100

S. No	Fuel Consumption	Fuel Power	Brake Power	Indicated Power	Brake Thermal Efficiency	Indicated Thermal Efficiency	Mechanical Efficiency	Indicated Specific Fuel Consumption	Brake Specific Fuel Consumption
	$\times 10^{-4}$ Kg/sec	KW	KW	KW	%	%	%	$\times 10^{-5}$ Kg/kw.sec	$\times 10^{-4}$ Kg/kw.sec
1	1.83	8.05	1.02	5.2	12.67	64.58	19.62	3.52	1.79
2	2.47	10.87	2.07	5.2	19.05	47.85	39.81	4.75	1.19
3	3.11	13.68	3.09	5.2	22.58	38	59.42	5.98	1.01
4	3.84	16.89	4.14	5.2	24.50	30.78	79.62	7.38	0.93
5	4.56	20.06	5.19	5.2	25.86	25.92	99.81	8.77	0.88

TABLE (5) DIESEL

S. No	Fuel Consumption	Fuel Power	Brake Power	Indicated Power	Brake Thermal Efficiency	Indicated Thermal Efficiency	Mechanical Efficiency	Indicated Specific Fuel Consumption	Brake Specific Fuel Consumption
	$\times 10^{-4}$ Kg/sec	KW	KW	KW	%	%	%	$\times 10^{-5}$ Kg/kw.sec	$\times 10^{-4}$ Kg/kw.sec
1	1.76	7.74	1.02	5.2	13.17	67.15	19.62	3.38	1.73
2	2.09	9.19	2.07	5.2	22.51	56.55	39.81	4.02	1.01
3	2.73	12.01	3.09	5.2	25.72	42.29	59.42	5.25	0.88
4	2.86	12.58	4.14	5.2	32.89	41.32	79.62	5.5	0.69
5	3.27	14.39	5.19	5.2	36.07	36.07	99.81	6.29	0.63

PERFORMANCE CHARACTERISTICS

Brake thermal efficiency shows the performance of the particular fuel. Brake thermal efficiency increasing with increase of load. The variation of the brake thermal efficiency with respect to load for diesel fuel and pongamia methyl ester-diesel fuel blends. It can be observed from the figure that, diesel shows higher brake thermal efficiencies at all load conditions compared to that of pongamia biodiesel fuel. Almost all blends show slightly better BTE than diesel at higher load conditions. The higher thermal efficiencies may be due to the additional lubricity provided by the fuel blend.

BTE for pongamia biodiesel is lower than the diesel. This may be due to higher viscosity and its reduced energy content and lower calorific value compared to diesel. This results in poor atomization, incomplete combustion and lower heat release.

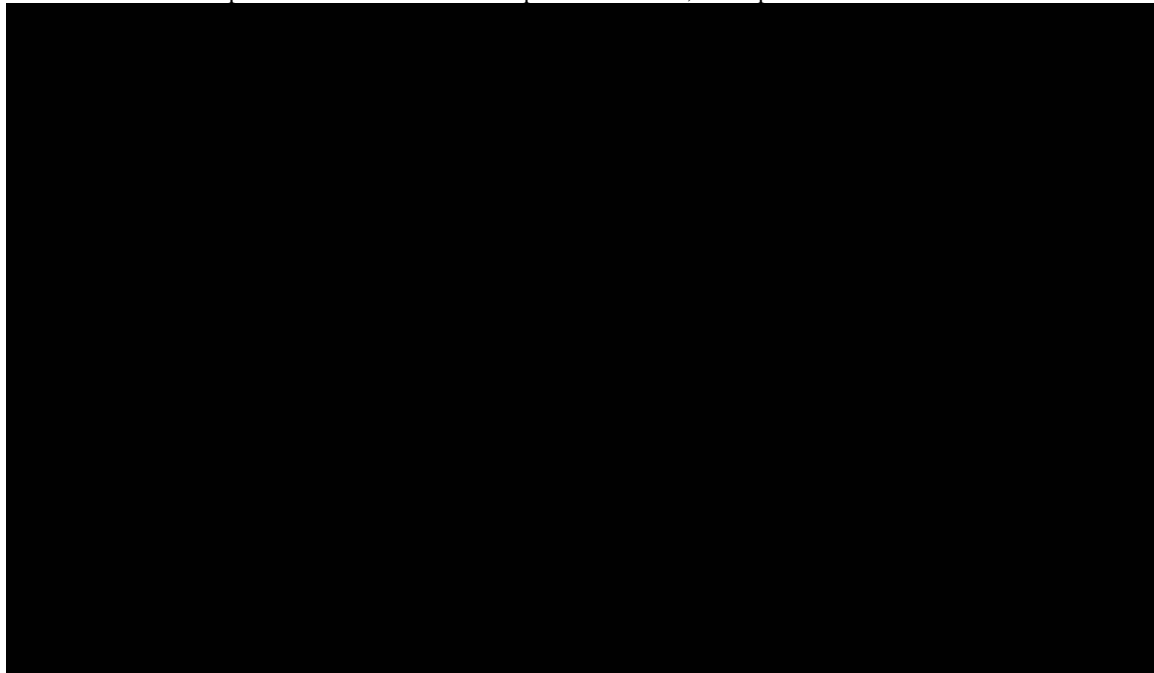


Fig (7) Brake Power Vs Brake Thermal Efficiency

The variation of the brake specific fuel consumption with different loads and two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific energy consumption (BSEC) will give more reliable value. The brake specific fuel consumption was determined for pongamia bio diesel -diesel fuel blends as the product of the specific fuel consumption and the

calorific value. It can be observed from the figure that the BSEC for diesel is lower as compared to that of biodiesel. The availability of the oxygen in the pongamia methyl ester-diesel fuel blend may be the reason for the lower BSEC.

In the case of lower load conditions, the incomplete mixture of high viscosity KME may lead to incomplete combustion and require additional fuel air mixture to produce the same power output as that of diesel fuel.

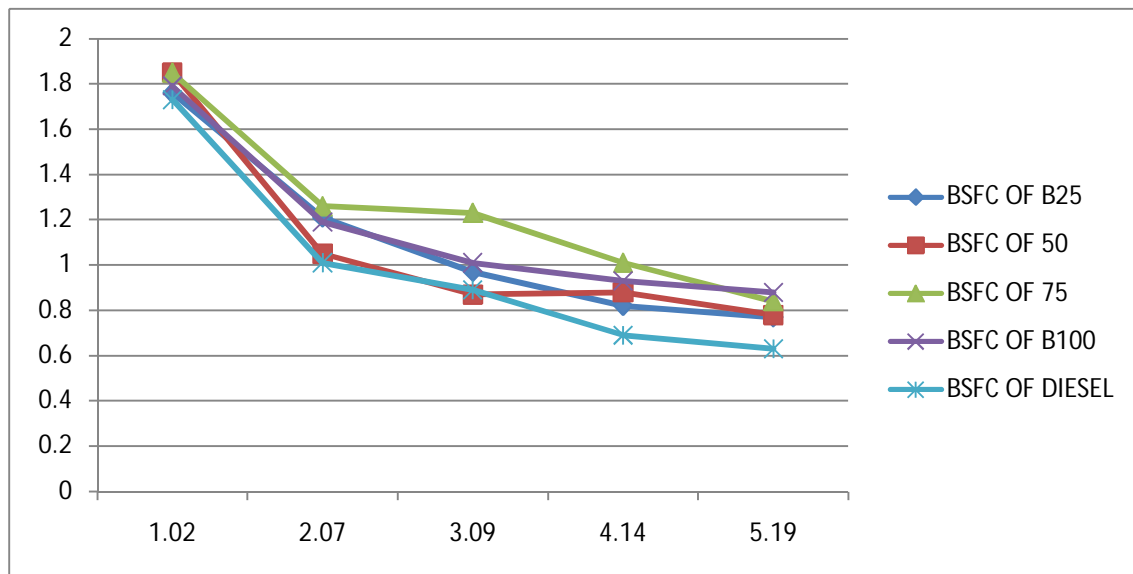


Fig (8) Brake Power Vs Brake Specific Fuel Consumption

Indicated thermal efficiency is decreasing while increasing the load. It is seen that indicated thermal efficiency for diesel is lower than the pongamia biodiesels. Indicated thermal efficiency of diesel is lower compare to the pongamia biodiesel. This may be due to high viscosity compare to diesel. It gives poor atomization and hence increasing ignition delay.

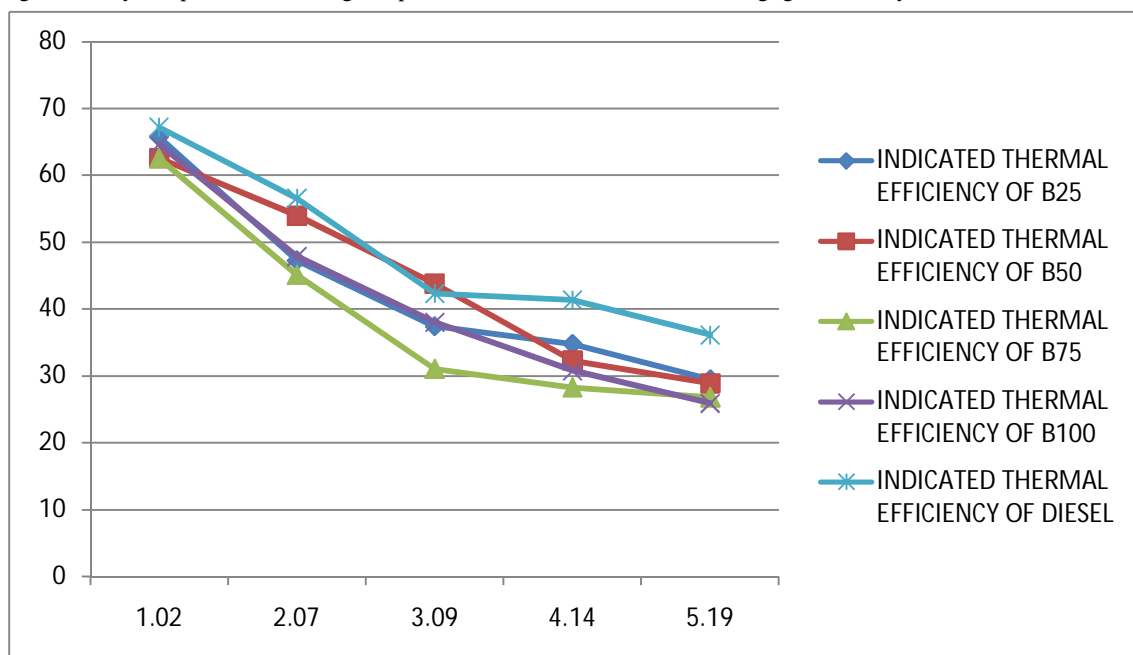


Fig (9) Brake Power Vs Indicated Thermal Efficiency

EMISSION CHARACTERISTICS

The below graph states that the brake power vs carbon mono oxide of the four blends and diesel. Comparing the four blends with diesel B50 gives the lower carbon mono oxide among the other blends such as B25, B75, B 100.

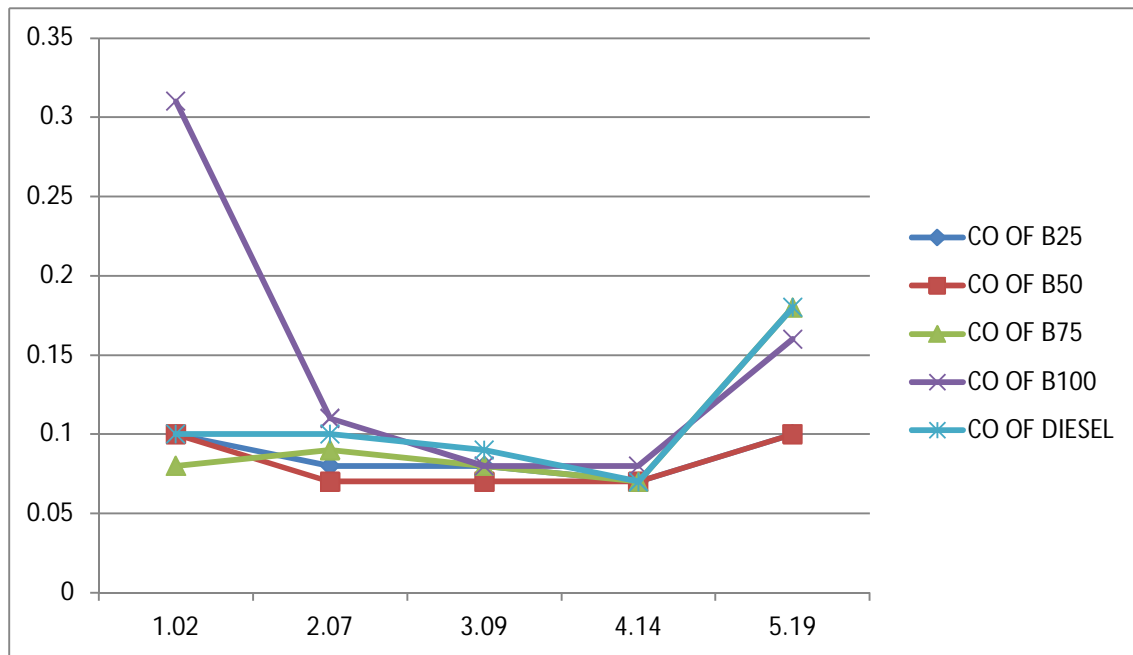


Fig (10) Brake Power Vs Carbon Mono Oxide

From the below graph we can easily observe that the hydro carbon from blend B25 is lower than the other blends whereas diesel gives high amount of hydro carbon.

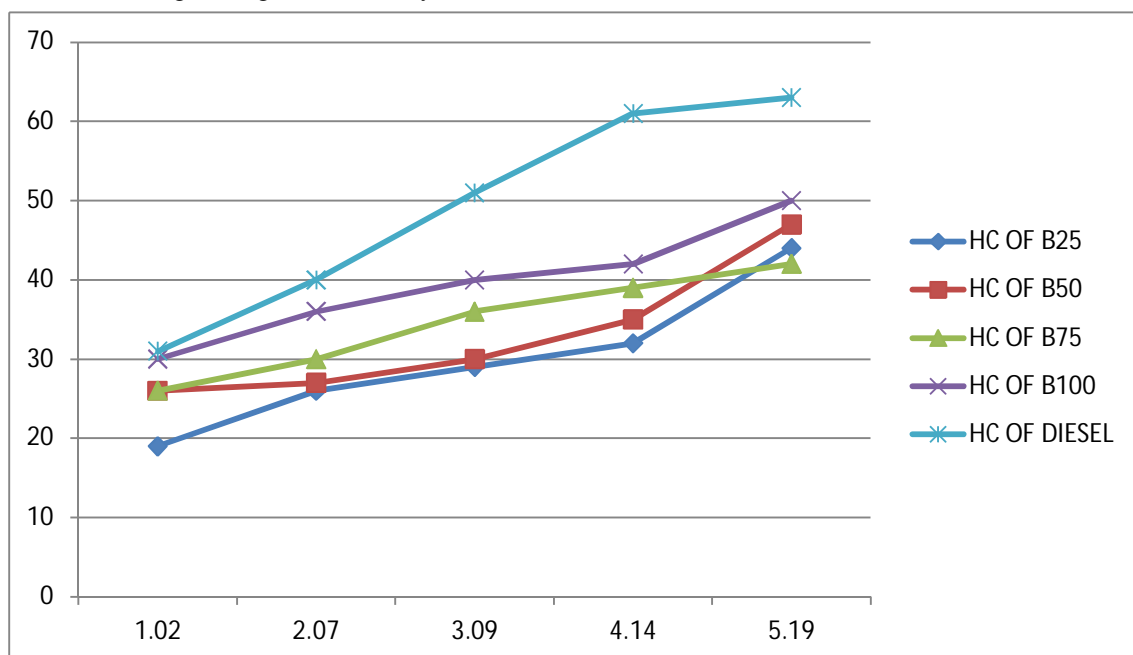


Fig (11) Brake Power Vs Hydro Carbon

The below graph determined the value of the brake power vs carbon di -oxide by comparison of four blends. The range of all the blends is same throughout the brake power, whereas the diesel rises at the point of brake power 4.14.

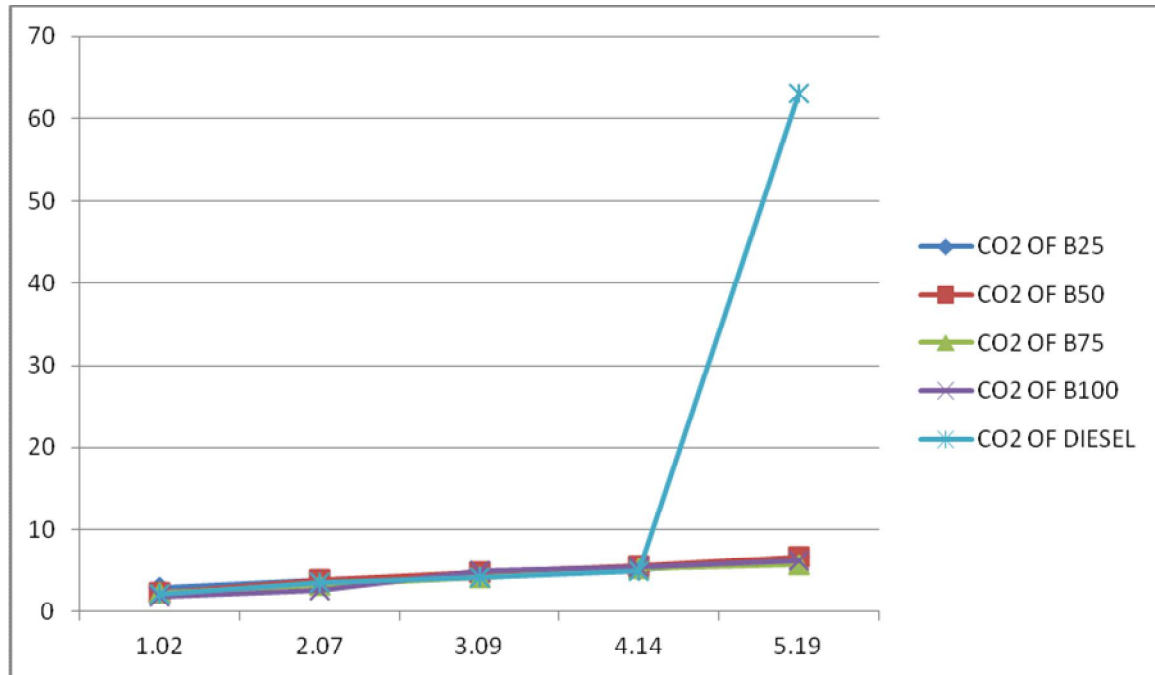


Fig (12) Brake Power Vs Carbon Di Oxide

From the below graph, observed that the range of oxygen level for four blends. From the observation the blend B100 gives the oxygen emission as much as possible.

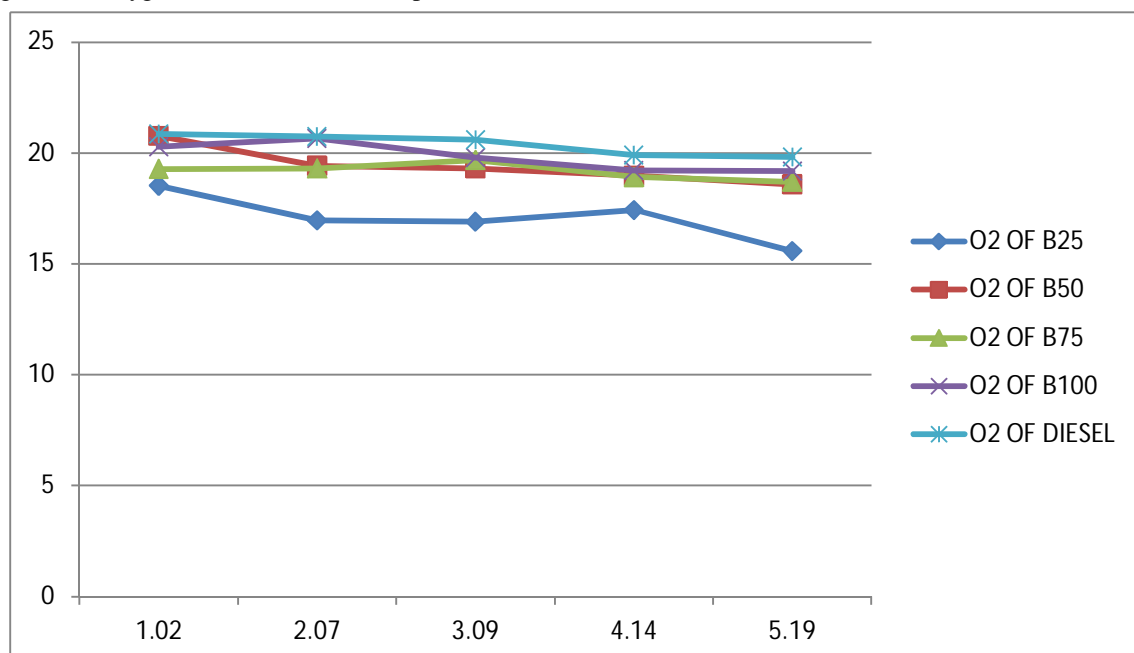


Fig (13) Brake Power Vs Oxygen

The below graph states that the value of comparison of four blends for nitrogen oxide. From the graph the Blend B100 is much better than the diesel and then compare to other blends.

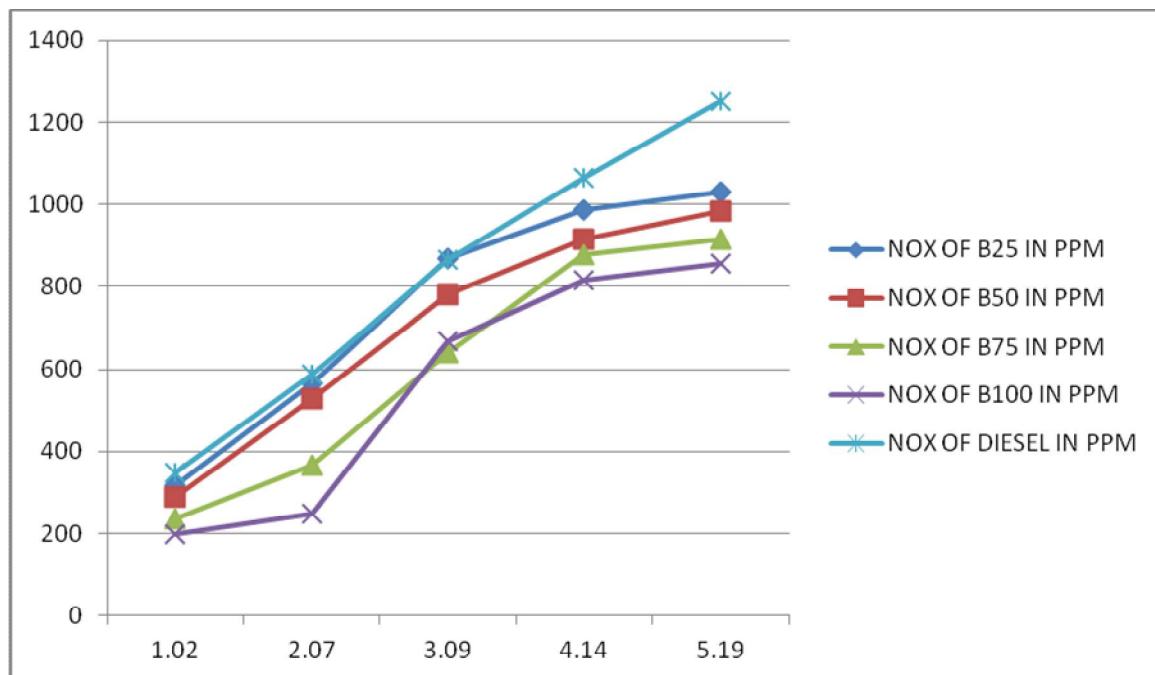


Fig (14) Brake Power Vs Nitrogen Oxide

IV. CONCLUSION

From the analysis of the performance and emission characteristics graph, we studied some information regarding biodiesel base from pongamia oil. From the performance analysis, graphs of brake thermal efficiency, brake specific fuel consumption and indicated thermal efficiency were calculated using constant brake power. From the observation of the graph, the blends B25 and B50 are much nearer to the diesel. But in case of emission characteristics the blends B25 and B50 are not suitable.

For emission characteristics, we analysis the emission gas by using five gas analyzer to find out the five different types of emission gas such as carbon mono oxide(CO), hydro carbon(HC), carbon di-oxide(CO₂), oxygen(O₂) and nitrogen oxide(NO_x). The calculated graph of emission characteristics graph states the blend B100 is suitable for CI engine to give less toxics substance which is near to the diesel. From the paper we have observed both performances and emission characteristics, B50 is chosen as a right fuel proportion to run the CI engine with less toxics gas next to the B100.

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REFERENCES

- 1) Arun k. vuppaladadiyam, Sangeetha CJ , Sowmya V,(2013), Transesterification of pongamia pinnata oil using base catalyst: a laboratory scale study, Universal journal of environmental research and technology, volume 3, issue 1:113-118.
- 2) Bobade S.N and Khyade V.B, (2012), Preparation of methyl ester (biodiesel) from karanja (pongamia pinnata) oil, Research journal of chemical sciences,vol.2(8), 43-50.
- 3) Gaurav Dwivedi, Siddharth Jain, Mahendra Pal Sharma (2011), Pongamia as a source of biodiesel in india, Smart grid and renewable energy,vol.2,184-189
- 4) L.C. Methar, Vidya S.S. Dharmagadda, S.N. Naik (2006), Optimization of alkali-catalyzed transesterification of pongamia pinnata oil for production of biodiesel,Bioresource technology,vol.97,1392-1397
- 5) L.karikalan and M.Chandrasekaran ,(2015), Karanja oil biodiesel: a potential substitution for diesel fuel in diesel engine without alteration, APRN journal of engineering and applied sciences, vol.10 no.1.
- 6) Savita Sangwan, D.V. rao and R.A. Sharma (2010) ,A review on pongamia pinnata (l.) pierre: a great versatile leguminous plant,Nature and science ,8(11):130-139 (ISSN: 1545-0740)
- 7) Venkates Ramesh Mamilla, M.V. Mallikarjun, Dr. G. Lakshmi Narayana Rao ,(2011), Preparation of bio diesel from karanja oil, International journal of energy engineering, vol.1 no.2, pp.94-100.
- 8) Vidhvath Viswanatham, Vinodh Mohan, Viswa Purusothaman, Subhasish Das,(2013), Bioprocess optimization for production from pongamia pinnata, International conference on environment, energy and biotechnolgy,IPCBE vol.51.