Performance Optimization and Emission Reduction on Diesel Engine using Diesel Blend

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Abstract - *In this paper, Performance Optimization and Emission reduction on Diesel engine using diesel blend is discussed. Biodiesel production nowadays become the modern and technological area for researchers due to constant increase in the prices of petroleum, diesel and environmental advantages. Biodiesel from Jatropha oil was produced by alkali catalyzed transesterification process used for the study on engine performance evaluation. Recently it is being considered as one of the most promising alternative fuels in internal combustion engine. Performance test and exhaust gas analysis was conducted with single cylinder water cooled diesel engine with Jatropha oil as fuel.*

***Key Words*: Bio diesel blend, Jatropha, Transesterification.**

1.INTRODUCTION

As civilization is growing, transport becomes essential part of life. The biggest problem is the growing population & depletion of fossil fuel. The rapid depletion of fossil fuel reserves with increasing demand and uncertainty in their supply, as well as the rapid rise in petroleum prices, has stimulated the search for other alternatives to fossil fuels. In view of this, there is an urgent need to explore new alternatives, which are likely to reduce our dependency on oil imports as well as can help in protecting the environment for sustainable development. Many alternative fuels are being recently explored as potential alternatives for the present high-pollutant diesel fuel derived from diminishing commercial resources.

Biodiesel emerges as one of the most energy-efficient environmentally friendly options in recent times to full fill the future energy needs. It is a renewable diesel substitute that can be obtained by combining chemically any natural oil or fat with alcohol. It is an alternative fuel for diesel engine. The esters of vegetable oils and animal fats are known collectively as biodiesel. It is a domestic, renewable fuel for diesel engine derived from natural oil like Jatropha oil. Biodiesel has an energy content of about 12% less than petroleum-based diesel fuel on a mass basis. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel. Pure biodiesel (B100) can be used in any petroleum diesel engine, though it is more commonly used in lower concentrations. Jatropha oil can also be used directly by blending with diesel.

Nowadays, global warming caused by CO_2 is the main climatic problem in the world. Therefore, environmental protection is important for the future of the world. Because the biodiesel is made from renewable sources, it is more convenient to protect environment from unwanted emissions. Biodiesel is an ecological and non-hazardous fuel with low emission values, and therefore it is environmentally useful. The usage of biodiesel does not require any changes in the fuel distribution infrastructure, and it is competitive with petroleum-derived diesel fuel. Furthermore, it biodegrades much more rapidly than petroleum diesel fuel. Thus, considerable environmental benefits are provided. Biodiesel has low emissions of carbon monoxide (CO), particulate matter (PM) and unburned hydrocarbons (UHC). Some investigators have claimed that the photosynthesis recycles carbon dioxide produced by combustion of biodiesel. Therefore, biodiesel usage may reduce the greenhouse effect.

The growing concern due to environmental pollution caused by the conventional fossil fuels and the realization that they are non-renewable have led to search for more environment friendly and renewable fuels. Among various options investigated for diesel fuel, biodiesel obtained from jatropha has been recognized. The performance and characteristics are tested by using compression ignition engine. Biodiesel was made by transesterification process. The effect of test sample and commercial diesel on the engine power, fuel consumption, efficiency and exhaust gas temperature were ascertained by performance tests. The influence of blends emission CO, HC and NO were investigated by gas analyzer.

Thus the objective is to conduct a test in order to increase the efficiency of a diesel engine and help in controlling the emission of particulates in a considerable Amount. This is to be done by adding a certain diesel blend (here it will be jatropha oil) in consistent amounts and verify the conditions. Accordingly, tests are to be conducted to determine: Flash Point and Fire Point; Load Test; Emission of Particulates.

In **section 2,** the production of biodiesel and the application of biodiesel were explained. The preparation of jatropha oil and jatropha biodiesel from jatropha curcas. Fuel analysis and properties of various biodiesel were discussed in **Section 3.** In **Section 4,** the experimental setup of the diesel engine to carry out the performance and emission test for diesel and various jatropha blends, its testing procedure to carry out the results were explained. In **Section 5**, the results and discussions of the experiments carried out. **Section 6** contains the Conclusions of the Paper followed by references.

2. PRODUCTION OF BIODIESEL

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, ethyl, or propyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow) with an alcohol producing fatty acid esters. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used alone, or blended with petro diesel in any proportions.

2.1 Biodiesel Blends

Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix:

- 100% biodiesel is referred to as B100
- 20% biodiesel, 80% petro diesel is labeled B20
- 15% biodiesel, 85% petro diesel is labeled B15
- 10% biodiesel, 90% petro diesel is labeled B10
- 5% biodiesel, 95% petro diesel is labeled B5

Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, although certain manufacturers do not extend warranty coverage if equipment is damaged by these blends.

The commercial method used for the biodiesel production is the transesterification (also called Alcoholysis). The transesterification consists on the reaction of oils or fats with an alcohol of low molecular weight (usually ethanol or methanol) with the presence of an alkaline catalyst (usually NaOH or KOH) to produce esters and glycerin. The stoichiometric ratio for the transesterification is as shown.

1 OIL/FAT + 3 METHANOL 3 $\Longrightarrow$ METHYL ESTERS + 1 GLYCERIN

3. PREPARATION OF JATROPHA

Jatropha curcas is nonedible oil being singled out for large-scale for plantation on wastelands. Jatropha curcas plant can thrive under adverse conditions. It is a drought resistant, perennial plant, living up to fifty years and has capability to grow on marginal soils. It requires very little irrigation and grows in all types of soils (from coastline to hill slopes). The production of Jatropha seeds is about 0.8 kg per square meter per year. The oil content of Jatropha seed ranges from 30% to 40% by weight and the kernel itself ranges from 45% to 60%. Fresh Jatropha oil is slow drying, odorless and colorless oil, but it turns yellow after ageing.

Fig -1: Seeds of Jatropha **Fig -2:** Jatropha Oil

3.1 Jatropha Oil

Jatropha oil is vegetable oil produced from the seeds of the jatropha curcas, a plant that can grow in marginal lands. When jatropha seeds are crushed, the resulting jatropha oil can be processed to produce a high-quality biodiesel that can be used in a standard diesel car, while the residue (press cake) can also be processed and used as biomass feedstock to power electricity plants or used as fertilizer (it contains nitrogen, phosphorus and potassium).

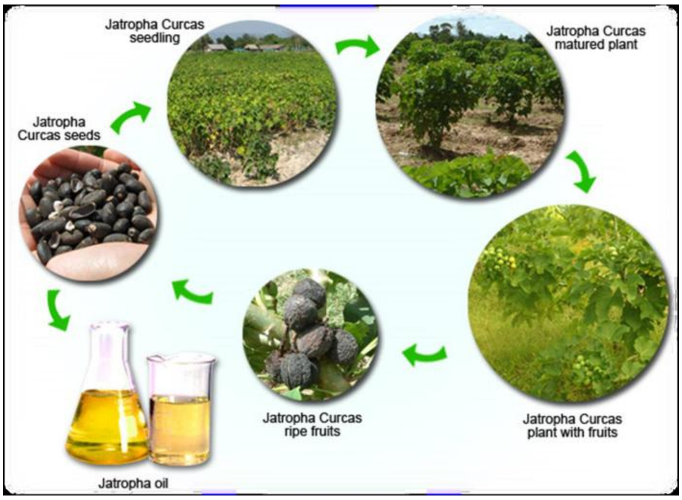

Fig -3: Jatropha Production Cycle

4. EXPERIMENTAL SETUP

After preparation of various blends of biodiesel it is tested in engine to check the performance of engine. The kirloskar make single cylinder diesel engine was used for experimentation. The technical details of engine are given in table. The filter of the diesel engine was disconnected from its diesel tank and connected directly to fuel measuring unit.

Table- 4: Technical specification of diesel engine

Sl No.	Parameter	Details
1	Make	Kirloskar
2	Type of engine	Single cylinder, 4 Stroke
3	No. of cylinders	1
4	Power	5 HP
5	Rated speed	650 rpm
6	Bore Diameter	80 mm
7	Stroke length	110
8	Orifice diameter	17 mm
9	Starting	Cranking
10	Type of Loading	Rope Brake Loading
11	Type of Cooling	Water Cooling
12	Type of Ignition	Compression Ignition
13	Compression Ratio	16:5:1
14	Dia. of Drum	0.3m
15	Dia. of Rope	0.016m
16	Cd of Orifice	0.62
17	Density of Diesel	0.82 gm/cc
18	Cv of Diesel	43953 KJ/kg

Fig -4: Photographic view of the Test Engine

4.1 Test Procedure

At first the diesel engine with the particular specifications are set to be conduct the experiment. The diesel engine is cleaned thoroughly and made ready.

The engine started taking following precautions.

- Check the fuel level.
- Check the lubricating oil level.
- Check the cooling water circulation.
- Check whether the engine is on no load

The flash point and fire points of diesel in its pure form, and then when added with jatropha are looked into using the pensky-marten apparatus.
After starting the engine the time taken for the consumption of 10cc of fuel is recorded at no load. Now load the gradually and take the time for the consumption of 10cc of fuel at constant rpm. Care should be taken that the engine is not overloaded.
The engine was run initially using diesel for 10 minutes each for 25, 50, 75 and 100% load. The fuel consumption was measured by using stopwatch. During the initial and the final load applications, the AVL analyzer is used to detect the amount of effluent gases. The cooling water temperature at the outlet was maintained at 70⁰C. The engine was stabilized before taking all measurements. Different blends of jatropha oil biodiesel with diesel were prepared namely B0, B10, B20, B30, B40 and B50.Before using blend, each one was mixed thoroughly. The filter of diesel engine was opened and complete mixture of biodiesel and diesel was drained so that it could not mix with the next blend. The experiment was repeated for each blend.

4.2 Performance Test

Fig- 5: Pensky–Martens closed cup apparatus

- The flash point of diesel is 60 °C.
- The fire point of diesel is 70 °C.

4.3 Emission Test

The emission tests were conducted on a Kirloskar, four stroke, 4 cylinder petrol engine test-rig with rope braking loading system. AVL 444 Digas exhaust analyzer is used for measuring the emission of exhaust gas. The gas analyzer is capable of measuring CO, CO_2, HC, NO_x and O_2 and is interfaced with RS232 cable. The temperature of the catalyst has been measured with K type thermocouple and the data are stored using data logger.

Fig- 6: Photographic View of the AVL Exhaust Gas Analyzer

5. RESULTS AND DISCUSSIONS

5.1 Flash and Fire Point

It is known that the flash point of the diesel is 60⁰C and fire point is 70⁰C. Now when the blend is added to diesel in varied proportions, we have the following fire and flash points obtained. The readings were obtained using the pensky-marten apparatus.

1. Diesel with 10% jatropha
   - Flash point : 61 ºC
   - Fire point : 70 ºC
2. Diesel with 20% jatropha
   - Flash point : 64 ºC
   - Fire point : 80 ºC
3. Diesel with 30% jatropha
   - Flash point : 66 ºC
   - Fire point : 81 ºC
4. Diesel with 40% jatropha
   - Flash point : 68 ºC
   - Fire point : 84 ºC
5. Diesel with 50% jatropha
   - Flash point : 71 ºC
   - Fire point : 85 ºC

5.2 Performance of Diesel

Table 5: Performance of Diesel

Sl No.	Load W1	Load W2	Load Net load	Time For 10 cc Fuel Consumption (t)	BP	TFC	SFC	Brake MEP	IP	BTE	Mech. Efficiency	ITE	Exhaust Gas Temp.
	Kg	Kg	Kg	sec	w	Kg/hr	Kg/Whr	N/m²	w	%	%	%	K
1	0	0	0	72	0	0.415	-	0	1510	0	0	30.46	369
2	7	3	4	69	526.18	0.433	0.000829	67970	2036.18	10.17	25.84	39.36	406
3	12	4	8	60	1052.36	0.498	0.000473	135950	2562.36	17.69	41.06	43.07	435
4	16	4	12	54	1578.57	0.553	0.000350	203930	3088.57	23.89	51.11	46.75	454
5	20	4	16	48	2104.70	0.622	0.000295	272690	3614.70	28.32	58.22	48.65	504
6	25	5	20	43	2630.93	0.694	0.000263	340820	4140.93	31.73	63.53	48.95	518

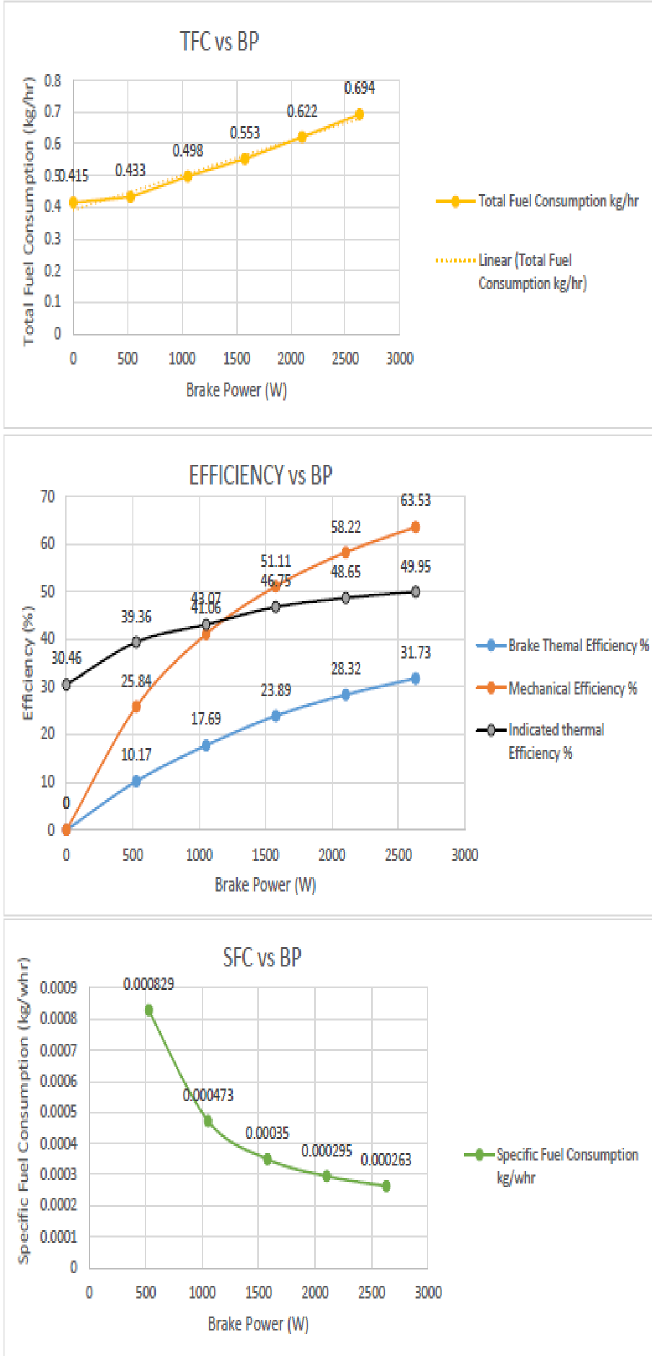

Chart -1: Performance Curve for Diesel

Table 6: Performance of 80% Diesel & 20% Biodiesel

Sl No.	Load W1	Load W2	Load Net load	Time For 10 cc Fuel Consumption (t)	BP	TFC	SFC	Brake MEP	IP	BTE	Mech. Efficiency	ITE	Exhaust Gas Temp.
	Kg	Kg	Kg	sec	w	Kg/hr	Kg/Whr	N/m²	w	%	%	%	K
1	0	0	0	80	0	0.38	-	0	1750	0	0	38.41	359
2	7	3	4	78	526.2	0.39	0.000744	67970	2276.18	11.28	23.11	48.61	393
3	12	4	8	67	1052.4	0.45	0.000433	135950	2802.36	19.3.0	37.55	51.53	420
4	16	4	12	59	1578.6	0.51	0.000328	203930	3328.57	25.50	47.42	53.88	444
5	20	4	16	52	2104.7	0.58	0.000279	272690	3854.7	30.01	54.60	55.16	469
6	25	5	20	48	2630.9	0.63	0.000242	340820	4350.93	34.63	60.05	57.61	492

Chart -2: Performance Curve of 80% Diesel & 20% Biodiesel

5.3 Comparison

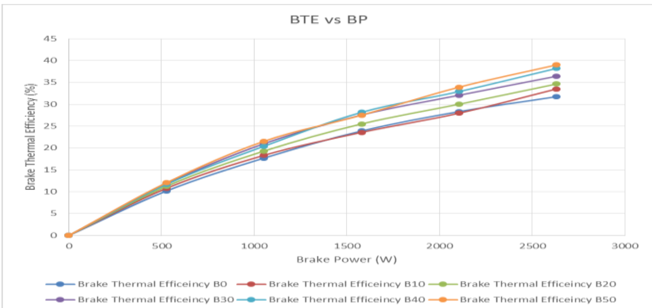

Chart -3: Brake Thermal Efficiency V/S Brake Power

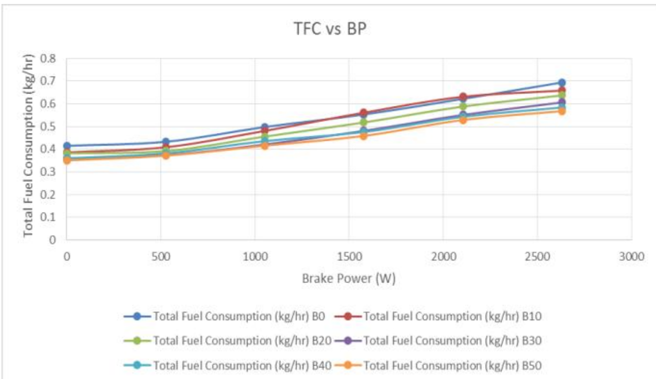

Chart -4: Total Fuel Consumption V/S Brake Power

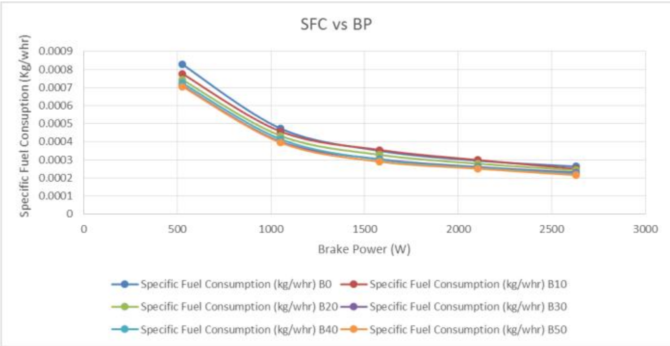

Chart -5: Specific Fuel Consumption V/S Brake Power

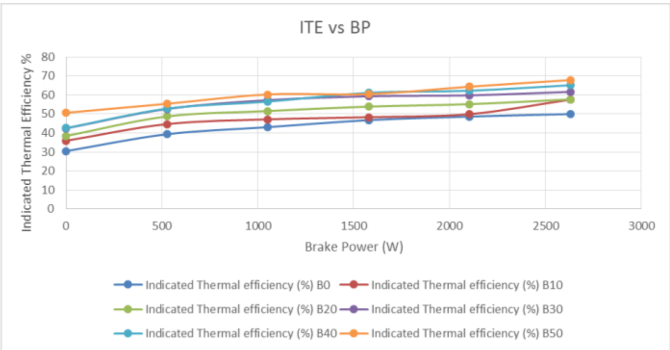

Chart -6: Indicated Thermal Efficiency V/S Brake Power

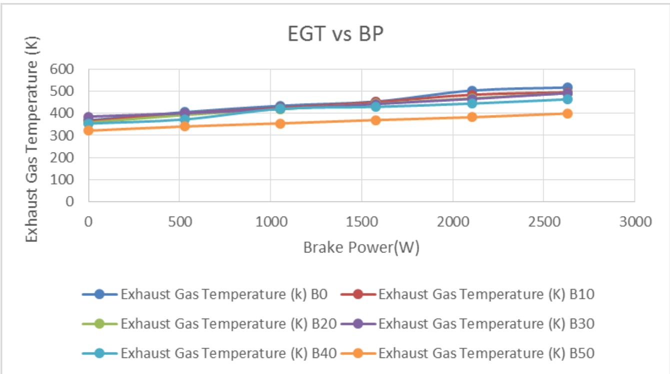

Chart -7: Exhaust Gas Temperature V/S Brake Power

- It can be noted that the efficiency of the diesel engine can be increased when around 60% of diesel blend, i.e. jatropha, is added to fuel. However, due to the density capacity that can be considered by the engine, more than 60% cannot be added since the density will gradually increase
- The flash and fire points have their advantages when the diesel bend is added, which can be clearly noted. This helps in favour of the engine.
- Most of all, with the addition of the diesel bend, it can be seen that the efficiency of the engine is much better than when only diesel was added.

5.4 Emission Results

Using the AVL Gas Analyzer Di-Gas 444, the tests were conducted for 100% diesel and 50% diesel and 50% jatropha conditions, for no load and 6-load stages. The following results were obtained.

Hydrocarbon emission (HC)

Biodiesel blends give lower HC emission as compared to diesel. Due to better combustion of the biodiesel inside the combustion chamber and the availability of the excess oxygen content in the biodiesel blends as compared to diesel. There are two reasons for hydrocarbon emissions:

(1) The leaner fuel mixture than required during combustion in diesel engine.
(2) Under-mixing of fuels.

HC emission of biodiesel is lower than diesel due to better combustion of biodiesel

Carbon Dioxide emission (CO_2)

Carbon dioxide is a by-product of efficient and complete combustion. At all loads biodiesel blends give less CO2 as compared to diesel.

Carbon monoxide emission (CO)

Biodiesel blends give less carbon monoxide as compared to diesel due to complete combustion. CO emission is due to improper combustion of fuel and it mainly depends on many engine temperature, and A/F ratio. With increases the percentage of biodiesel blend, carbon monoxide decreases. The more amount of oxygen content of biodiesels result in complete combustion of the fuel and supplies the necessary oxygen to convert CO to CO_2.

NOx Emissions

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 time. At higher loads, more fuel is burnt and higher temperature of the exhaust gases which result in higher production of nitric oxide. The NO_x from biodiesel are found greater than petroleum diesel at all load conditions. This is mainly due to presence of oxygen and higher cetane number of biodiesel blends.

5.6 Advantages

By adding the appropriate jatropha in required amounts, we have found several significant changes. As such, the advantages can be as given below:

1. The CO_2 emissions are lower for biodiesel blends as compared with diesel.
2. The Hydrocarbon emissions are less than diesel fuel as compared with biodiesel
3. The CO emissions are lower for biodiesel blends as compared with diesel.
4. Fuel cost can be reduced.
5. Diesel engine efficiency increases

6. CONCLUSIONS

In this present work, the jatropha biodiesel represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. The advantage of adding the blend to the fuel was obtained during optimization, which was a definite success. The compression ignition engines can perform well on jatropha biodiesel without any modifications in engine. From the above analysis the biodiesel shows better performance compared to diesel in the sense of better performance characteristics. Here one blended biodiesel in diesel engine was tested and tabulated. Various performance characteristics were also plotted. Comparing the plots it was noticed that the 20:80 biodiesel blend gives more efficiency than the diesel engine and the engine performance is smooth. Hence the biodiesel can be used as a substituent for diesel.

REFERENCES

[1] Schwab A.W., M.O. Bagby, B. Freedman. 1987. Preparation and properties of diesel fuels from vegetable oils.

[2] Demirbas, A. 2006. Biodiesel production via non-catalytic SFC method and biodiesel fuel characteristics.

[3] Avinash Kumar Agarwal, "Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines" Renewable Energy, 27 November 2006.

[4] Jincheng Huang, Yaodong Wang, Shuangding Li, Anthony P.Roskilly,Hongdong Yu, Huifen Li, "Experimental Investigation on the Performance and Emissions of a Diesel Engine Fuelled with Ethanol-diesel Blend," ATE 2697, 2008.

[5] Tiwari, A., Akhilesh, K., & Raheman, H. (2007). Biodiesel production from jatropha oil (Jatropha curcas) with high free fatty acids: An optimized process. Biomass & Bioenergy, 569-575.

BIOGRAPHIES

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