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Alternative Fuel-Manufacture of Bio-Diesel From Jatropha Curcas

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Abstract

The importance of diesel fuel in Indian context is very different from that in developed countries. Diesel is being used in mechanized agriculture, public transportation sectors and also for several other applications. In the wake of present fuel crisis, it has become essential to identify some renewable and environmentally compatible substitutes to diesel fuel. In the present investigation, the high viscosity of Jatropha curcas oil which has been considered as a potential alternative fuel for the diesel engine was decreased by **transesterification.** The biodiesel can be obtained from the oil extracted from the plant in the following methods: base catalyzed transesterification of the oil with methanol, acid catalyzed transesterification of the oil with methanol and conversion of oil to fatty acids, then to biodiesel with acid catalyst. Among these methods, the first method of manufacturing is predominantly used since 98% of oil can be converted to biodiesel and exotic materials of construction are not necessary. We also used ethanol instead of methanol and obtained the biodiesel with better yield and better characteristics than methanol based biodiesel. So, we strongly suggest using pure biodiesel instead of ordinary diesel thereby uplifting our country's economy.

Introduction:

The General Definition Of Bio-Diesel is a renewable fuel for diesel engines derived from natural vegetable/animal oils, and which meets the standard specification. Technically it can be defined as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animals fats, and meeting the requirements of standard specifications

Need for the biodiesel:

- It can be stored just like the petroleum diesel fuel and hence does not require separate infrastructure.
- The use of bio-diesel in conventional diesel engines results in substantial reduction of un-burnt hydrocarbons, carbon monoxide and particulate matters (but NOX about 2 % higher)
- Biodiesel has almost no sulphur (0.05%) , no aromatics and has about 10 % built-in oxygen which helps in better combustion.
- Its higher Cetane number (> 51 as against 48 in diesel) improves the ignition quality even when blended in the petroleum diesel.

- Require very little or no engine modifications because bio diesel has properties similar to petroleum diesel fuels.
- Its higher flash point (>100 as against 35 in diesel) is good from safety point of view

Comparison:

VEGETABLE OIL	BIODIESEL	DIESEL FUEL
Triglyceride of fatty acid (Molecular Wt 700-1000)	Alkyl esters of Fatty acid Molecular Wt~260 to 300	Saturated Hydrocarbon (C12-C14) Molecular Wt~200
10% less heating value than diesel because it contains Oxygen	10-12 % less heating value than diesel	Major hydrogen and carbon (SOx, NOx, PAH)
Kinematic viscosity is higher (35-45 cSt at 40degrees)	Kinematic viscosity is in same range of that of diesel	Kinematic viscosity is lower (3.8 -5 cSt at 40degrees)
Less volatility	Less volatile than diesel	High volatility

Vegetable oils suitable for biodiesel production:

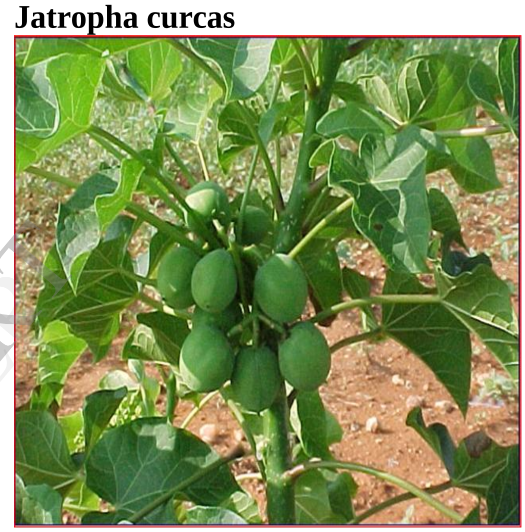
Possible raw materials for biodiesel

- Ratanjyot
- Jatropha curcas
- Karanja
- Pongamia glabra
- Mahua
- Madhuca indica
- Pilu
- Salvadora oleoides
- Sal
- Shorea robusta
- Nahor
- Mesua ferra linn
- Kamala
- Mallotus phillipines
- Kokam
- Garcinia indica
- Rubber Seed
- Hevea Brasilensis

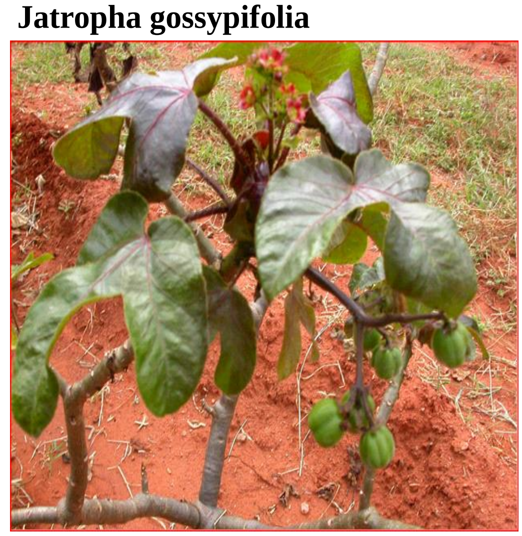
Types of jatropha:

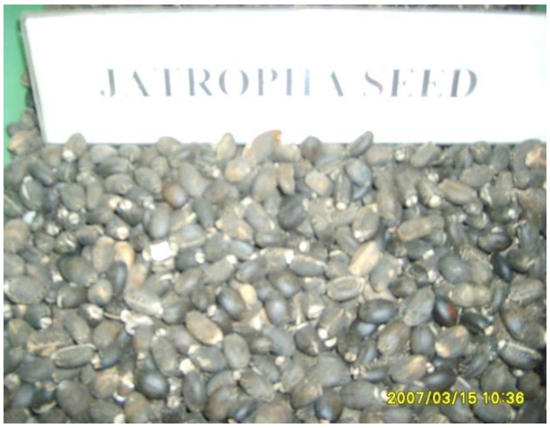
- Jatropha curcas
- Jatropha curcas (nontoxic)
- J. curcas x J.integrerrima
- Jatropha gossypifolia
- Jatropha glandulifera
- Jatropha tanjorensis
- Jatropha multifida
- Jatropha podagrica
- Jatropha integerrima

Jatropha curcas



Jatropha gossypifolia





Jatropha curcas:

Properties:

Colour	Pale yellow -yellowish brown
Specific gravity at 15°C	0.18-0.923
Refractive index at 40°C	1.462-1.465
Titler °C	31
Iodine value	93-107
Saponification value	188-196
Hydroxyl value	4-20
Unsaponifiable matter	0.4-1.1%
Fatty acids	**Percentage**
Myristic	0.5-1.4
Palmitic acid	12-17
Stearic acid	5-9.7
Arachidic acid	0-0.3
Oleic acid	37-63
Linoleic acid	19-41

Method of manufacturing of biodiesel:

The production of biodiesel, or alkyl esters, is well known. There are three basic routes to ester production from oils and fats:

- Base catalyzed transesterification of the oil with alcohol.
- Direct acid catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to Alkyl esters with acid catalysis.

Reasons for choosing base catalyzed method:

- Low temperature (150 F) and pressure (20 psi) processing.
- High conversion (98%) with minimal side reactions and reaction time.
- Direct conversion to methyl ester with no intermediate steps.
- Exotic materials of construction are not necessary.

Process planning of biodiesel manufacture

- **Obtaining vegetable oil:**

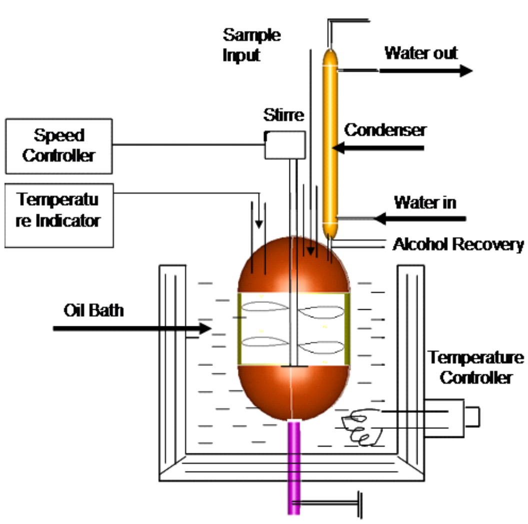
Oil is fed to the hopper and it is grinded to smaller particles using the aid of blades and it is then allowed to pass through an arrangement where it gets crushed due to high pressure. The high pressure is obtained by a compressor and oil is thus extracted from the seed.

2) Oil pre-treatment

The crushed oil is then passed through a tube to the filtering chamber and thus the oil is purified to an extent.

Trans-esterification:

It is one of the most reliable techniques to produce biodiesel from any foreign seeds. It is the reaction of the vegetable oil or animal fat with an alcohol (methanol or ethanol) in the presence of a catalyst to form a fatty acid alkyl esters, glycerol and fertilizer. The catalyst is used to improve the reaction rate and yield because the reaction is reliable, excess alcohol is used to shift the equilibrium to the product side.



The production of biodiesel from the jatropha oil was carried out by transesterification reaction. The reaction flask for this process was designed and fabricated by local glass blower, containing of heating mantle, reaction flask (made of stainless steel) and mechanical stirrer. The working capacity of the reaction flask is 6 litres. It consisted of 3 necks; one for stirrer and the others for condenser and inlet reactant as well as for placing the thermocouple to absorb the reaction temperature. The flask had a stop cork at the bottom for collection of final product. The production procedure for biodiesel from jatropha oil was done by the following steps.

SODIUM HYDROXIDE - ETHANOL SOLUTION:

The sodium hydroxide ethanol solution was made freshly to maintain the catalytic activity of the catalyst. The NaOH(30g) was added to 1500ml of methanol and the contact of the air in the catalytic solution was avoided to prevent the moisture absorbance. This catalytic solution was made for the reaction of 3 litres of jatropha oil.

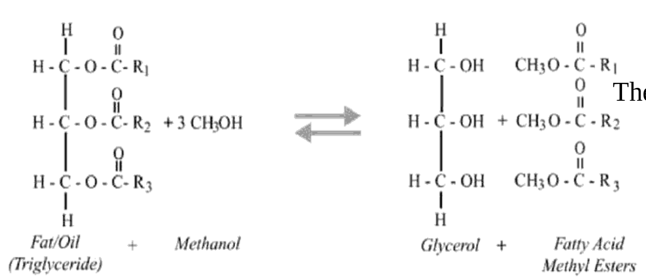
Types of catalysts

- Homogeneous Catalyst (KOH / NaOH)
- Acid Catalyst (HCl, H2SO4)
- Heterogenous Catalyst (CaO, ZnO)
- Enzymes (Lipase)
- Without catalyst (SCF of Methanol)

When the free fatty acid(FFA%) is less than 5%, NaOH can be used as catalyst and if the FFA% is greater than 5%, sulphuric acid can be used as the catalyst.

Transesterification reaction:

The oil was transesterified with ethanol for production of jatropha oil ethyl ester (pure biodiesel-JOME). In this process, 3 litres of jatropha oil was pre heated in the reactor to the required temperature before starting the reaction. Then the freshly prepared sodium hydroxide methyl solution was added to the reactor and the, measurement of time was recorded at this point. A set of process conditions for transesterification were optimized using a one litre per batch reactor for production of JOME. The same set of process conditions was used for the production of JOME in a large capacity (6 litres per batch) reactor. In this reactor, 3 litres of jatropha oil was measured and charged into the reactor. The above catalyst solution was added into the closed reaction vessel. The system from here onwards is totally closed into the atmosphere to prevent the loss of alcohol as well as to prevent the contact of moisture in air with reactant. The reaction flask was connected with a condenser and the stirrer. The heating was set up just above the boiling point of the alcohol i.e. 65-70 degrees to accomplish the reaction. The reaction was carried out with continuous stirring with a mechanical stirrer with a speed of 360 rpm up to 3 hours.



Separation:

The primary goal of this process is to remove esters from the mixtures, maintaining low cost and high purity of the products. Glycerol in its pure form is a secondary product of these reactions which has several industrial uses. The alcohol was recovered by a vacuum distillation. The products were transferred to a separating funnel and allowed to stand for 24 hours. The glycerine layer was much denser than biodiesel layer and the two could be easily separated. The lower glycerine layer was simply drawn off the bottom of the separating funnel. The remaining esters contain some excess catalyst and alcohol and these can be further purified by washing.

4) **Washing:**

The final biodiesel layer requires washing with water in order to remove the residual catalyst or soap and traces of ethanol. The amount of water required for washing was found to be approximately 8 times the volume of JOME. After washing, the final product was heated up to 70 degrees for 15 minutes and stored for further use. This resulted in a clear amber yellow liquid with a viscosity similar to petrodiesel.

Tests:

Once the oil is obtained, the performance and emission tests are carried out between the diesel and the obtained Jatropha oil. The procedures for the tests are as below:

The different phases for the tests on the above setup are carried out on the following phases:

1. Running the engine with diesel alone
2. Running the engine with different ratios: (Esterified Jatropha Oil: Diesel)

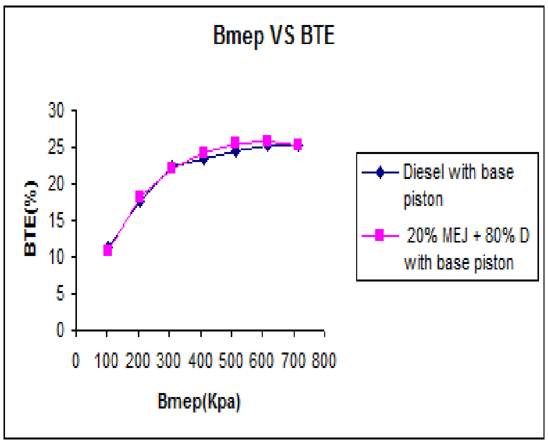
20:80
60:40
80:20
100:0

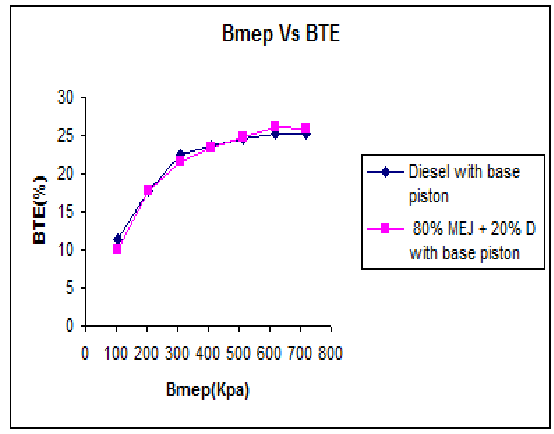
The tests are carried out by using two curves

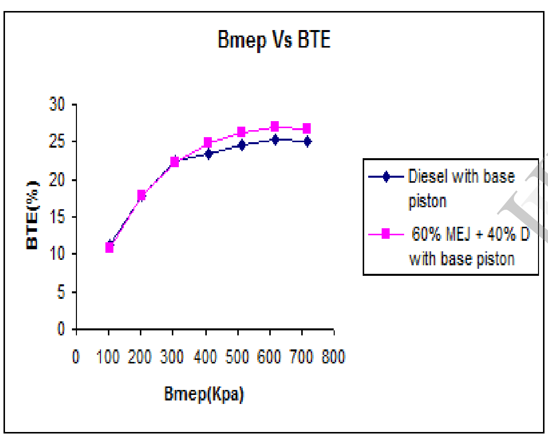
- Performance Curve
- Emission Curve

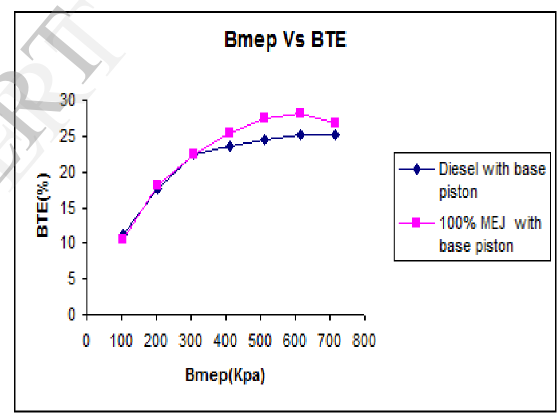
Performance curve:

Variation of break mean effective pressure vs brake thermal efficiency









The definition of BMEP Is: the average (mean) pressure which, if imposed on the pistons uniformly from the top to the bottom of each power stroke, would produce the measured (brake) power output.

Brake Thermal Efficiency is defined as the ratio of the heat equivalent of the brake output to the heat supplied to the engine.

Therefore from this chart we can understand that

- Brake thermal efficiency of the 100% MEJ in the presence of PSZ coating better the other. (10-20%)

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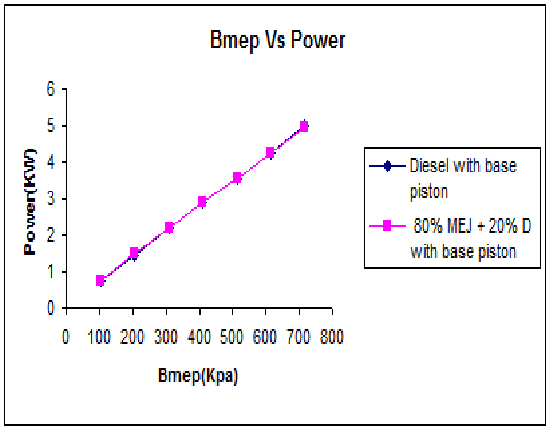
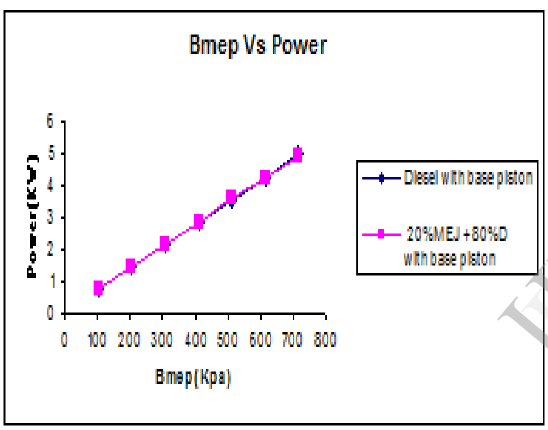
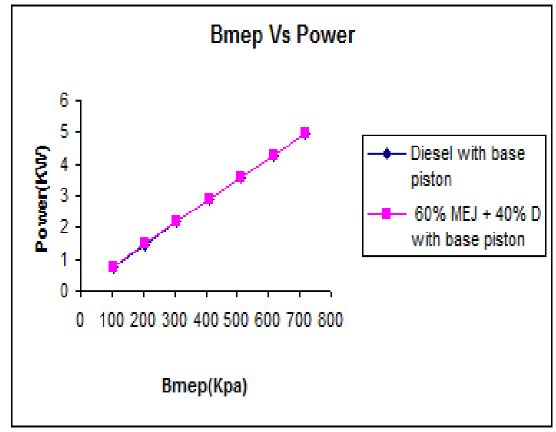
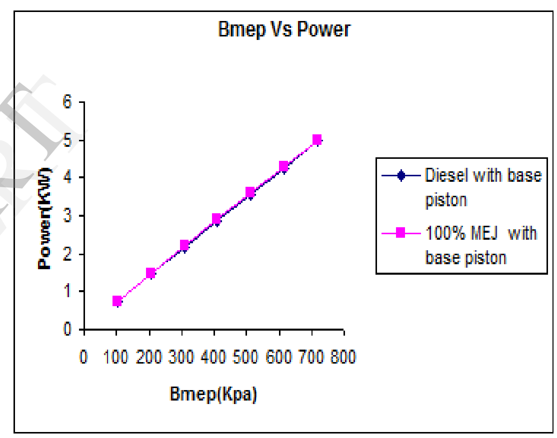
Variation of brake mean effective pressure vs power





Power is a measure of the rate of doing work expressed as the work done per unit time



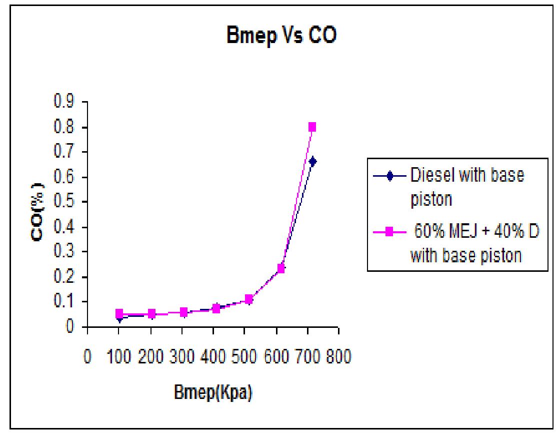


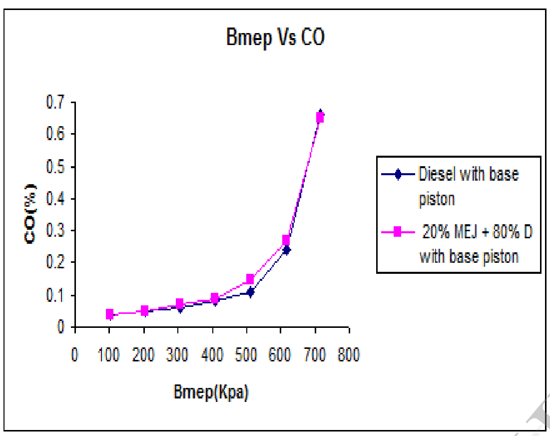
Therefore from the performance chart we can conclude that the engine with bio-diesel as its fuel has the same performance along with the diesel engine but has an improved performance with the brake thermal effieciency

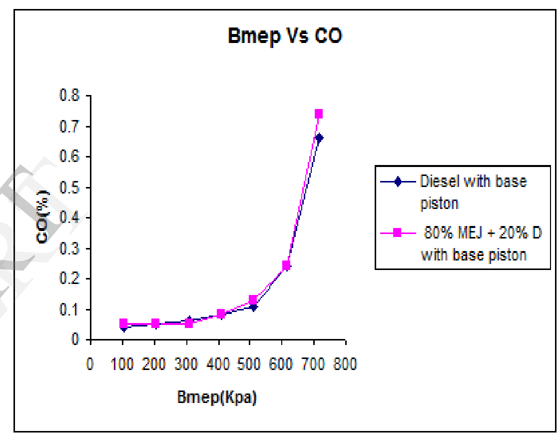
Emission curve:

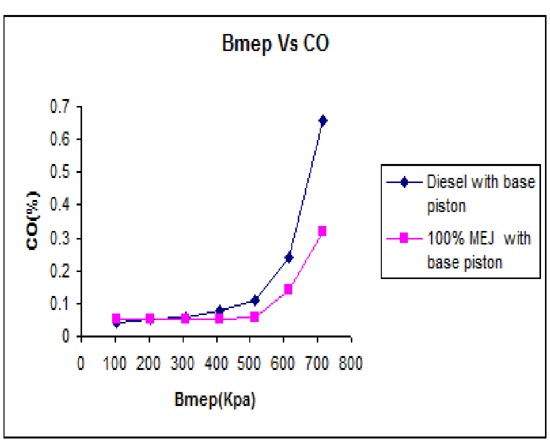
The main aim of this test is to find out the emission of the engines with bio-diesel and diesel as fuel. And this can be found out using the following category comparision

Variation of break mean effective pressure vs carbon- mono-oxide:





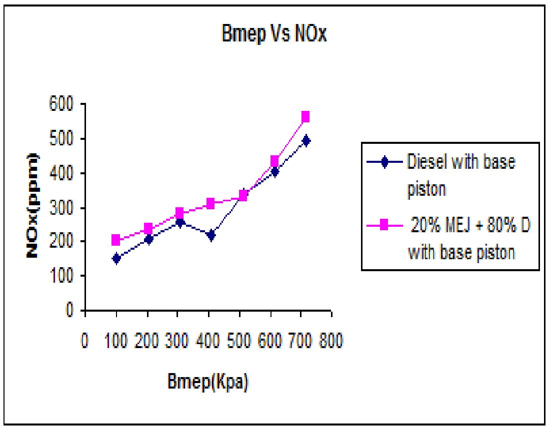


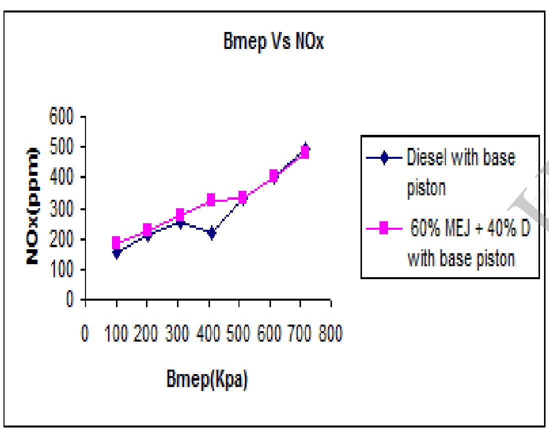


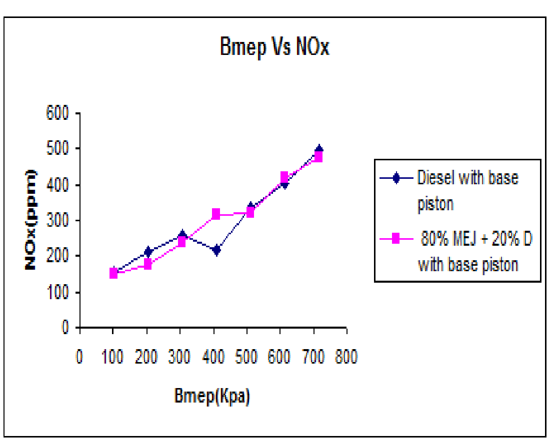
From this Graph the following conclusions can be obtained,

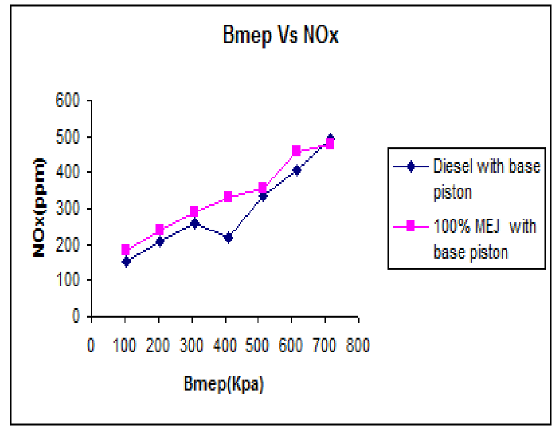
There is drastic reduction of CO in the case of coated piston with PSZ coating (60-75%)

Variation of break mean effective pressure vs oxides of nitrogen









Therefore the overall characteristics obtained from the Emission test is:

- The amount of Nox emitted increases for all blends in the case of coated piston.
- The amout of Emission is less in the engine with bio-diesel (jatropha) as fuel than the one with diesel.

Results and discussion:

As obtained from the graph we can find the advantages of the Jatropha oil over the Diesel and there by the overall properties of the obtained Bio-Diesel are:

- Specific fuel consumption remains more or less the same for all the cases.
- Similarly there is good reduction of HC in the case of coated piston (45-55%)

Conclusion:

- 100% BIODIESEL is the best alternative fuel for the diesel oil.
- Proper processing of Jatropha curcas seeds and transesterification can ascertain the quality of Liquid Biofuels.
- Decentralized processing unit will create enormous employment opportunity

- Finally, it is concluded that in terms of Performance and Emission characteristics, Jatropha oil can serve as a potential substitute for diesel fuel

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