COMPARATIVE PERFORMANCE EVALUATION OF JATROPHA OIL BLENDS WITH DIESEL IN C.I ENGINE

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ABSTRACT: India is one of the major countries facing vehicle pollution problems and spending most of its foreign currency on import of diesel products. In 1973, the oil crisis was started and depletion of ozone layer emphasized the necessity of alternative fuels. The Diesel Engines are dominating in transportation and agricultural machinery due to its fuel economy and cost effectiveness. The recent survey reveals that the diesel fuel consumption is several times higher than that of gasoline fuel. The Experimentation is going on jatropha oil and its blends with diesel which reduces the imports of petroleum products and expenditure of foreign currency. The direct use of these oils without any modification in diesel engines leads to poor performance and causes key damages on the parts of the engine. The Jathropa oil and vegetable biodiesel were blended with petroleum diesel in various proportions to evaluate and compared the performance and emission characteristics of a single cylinder direct injection constant speed diesel engine. The Diesel and Jathropa oil and vegetable biodiesel (10%, 20%, 30%, 40%, 50% and 60%) fuel blends were used to conduct engine performance and emission tests at varying loads. In this research work, the Jatropha and Diesel were tested in a single cylinder four stroke diesel engine and compared the results. The fire point of jatropha oil is more than that of diesel so this is very safe for transportation and storage and also the performance of engine with Jatropha oil is almost similar to that of diesel oil.

KEYWORDS: Jathropa Oil, Diesel, Performances, Single Cylinder Four Stroke Engines, Emission Characteristics.

INTRODUCTION: The first known use of vegetable oil as fuel in a diesel engine was a demonstration of an engine built by the Otto Company and designed to burn mineral oil, which was run on pure peanut oil at the 1900 world's fair. Late in his career, Rudolf Diesel investigated using vegetable oil to fuel engines of his design, and in a 1912 presentation to the British Institute of Mechanical Engineers, he cited a number of efforts in this area and remarked, "The fact that fat oils from vegetable sources can be used may seem insignificant today, but such oils may perhaps become in course of time of the same importance as some natural mineral oils and the tar products are now. Periodic petroleum shortages spurred research into vegetable oil as a diesel substitute during the 1930 and 1940 and again in the 1970 and early 1980 when straight vegetable oil enjoyed its highest level of scientific interest. The 1970 also saw the formation of the first commercial enterprise to allow consumers to run straight vegetable oil in their automobiles, Elsbett of Germany. In the 1990 Bougainville conflict, islanders cut off from oil supplies due to a blockade used coconut oil to fuel their vehicles. The academic research into straight vegetable oil fell off sharply in the 80s with falling petroleum prices and greater interest in biodiesel as an option that did not require extensive vehicle modifications. Biodiesel fuel is the future no question .Regular gasoline is becoming prohibitively expensive and looks to be becoming even more so. If you're looking for a way to contribute to a greener and less expensive future the biodiesel fuel is the way forward. There are 4 main agro – energy production chains such as Ethanol and the cogeneration of energy, Biodiesel from animal and plant sources, Forest biomass and, Residues and wastes from agriculture and agro –industry.

Ethanol is by far the most developed chain as it became commercial in the 1970, especially in Brazil, where the market has been consolidated since then. On the other hand, biodiesel and other agro – energy options are still incipient. The main drivers behind the bio-fuels production are they pollute a lot less, they are renewable, they high become competitive when petroleum prices increase, and petroleum price is very high at the moment. The Biodiesel is a renewable fuel produced by a chemical reaction of alcohol and vegetable (or animal) oils, fats or greases. Through a refinery process called Trans-esterification, the reaction removes the glycerin, a byproduct that can harm the engines. The resulting biodiesel can be used in any normal petrol diesel engine, in pure form or in different blends. The Biodiesel is safe, biodegradable, and considerably reduces serious air pollutants Blends of 20% biodiesel with 80% petroleum diesel (B20) can generally be used in unmodified diesel engines; however, users should consult their OEM and engine warranty statement .Biodiesel can also be used in its pure from (B100), but it may require certain rubber components of the engine to be modified to avoid maintenance and performance problems and may not be suitable for wintertime use. Biodiesel has physical properties very similar to conventional diesel and therefore the global market is poised for explosive growth in the next ten years; Although Europe currently represents 90% of global biodiesel consumption and production, the U.S is now ramping up production at a faster rate than Europe. Brazil is expected to surpass U.S and European biodiesel production by the year 2015.

In today's economy, fuel is main concern. Today's society is totally dependent on fuel for transportation, heating, and other petroleum products, petrochemicals and plastics. The world economy is dependent on petroleum in so many ways, that it is unimaginable to be without it now. A global petrochemical distribution infrastructure is already in place with fueling stations and tanks designed for liquids fuels. With bio-fuels we can use the system that is already there. The problem is that there is not enough worldwide production of vegetable oil and animal fat to replace the total consumption of petro diesel.

LITERATURE REVIEW:

Sun Jun Et-Al [1]: To use ethanol bio-diesel ethanol steam reforming engine was introduced. This engine is consists of a direct injection spark ignition engine and a set of ethanol supply system with an evaporator and a reactor. The engine is initially started by gasoline. When the exhaust gases reach 300˚C temperature, it can be used as energy source for ethanol steam waste heat from heat engine exhaust can be used as energy source for ethanol steam reforming engine. The energy consumptions is reduced about 6%

M.S. Murthl [2]: Karanja is a medium sized glabrous, perennial tree. The karanja seeds contain about 30-40% oil, which can be converted to biodiesel by trans- esterification with methanol. Different type of fuel blends are KO 10 (10% v/v of KO in diesel), KO20, KO30...KB 10, KB2 were used to conduct performance of single cylinder direct injection diesel engine at constant speed of 1500 rpm and emission tests at varying loads. In case of KB20, which had BTE almost same as diesel, BSEC is about 5% higher.

Qz Yang And B Song [3]: Bio fuels, such as biodiesel and biomass-based alcohol fuels are alternative sources. This assessment of main focus on the feedstock, demand, supply, and production technology on the sustainability of bio fuels, especially the WCO (waste cooking oils)-based biodiesels. The conversion from waste cooking oils to biodiesel is environmentally sustainable and also generation of low-carbon energy alternatives

Senthilkumar Et-Al [4]: To conduct performance test on horizontal single cylinder at variable speeds with the performance of cottonseed oil with diesel. On comparing the performance test of B5, B1O, B15, B20, B40 and B100 with diesel we come to know that TFC and SFC of B100 and B40 is very high compared to that of diesel. The usage of B20 blend will be more optimum compared to diesel. The overall comparison shows that B20 diesel has 20% yields the optimum value, with less fuel consumption and higher efficiencies than diesel.

A.R. Pradeep Kumar Et-Al [5]: Alternative fuel for diesel fuel is methyl ester made of vegetable oils. These oils shouldn't be used directly because it leads to poor performance and increase exhaust smoke. Rice bran oil is reacted with the alcohol in presence of the catalyst to produce the esters of vegetable. The low heat rejection (LHR) engines were developed with uniform ceramic coating of combustion chamber piston crown low heat rejection engines there is shortening of ignition delay, increase of diffusion burning period.

Hazir Farouk Et-Al [6]: Jatropha curcas is a plant native to Central America and West Asia, which yields multipurpose non-edible oil from its seeds.Jatropha curcas grows as a small tree or large shrub, up to 5–7m tall; with a soft wood and a life span of up to 50 years. Using non-food biomass feedstock such as Jatropha curcas could help to achieve sustainable, very low emission and cost-effective. From use of the oil and Jatropha by-products for generating electricity and as a viable alternative for firewood and charcoal.

Jerekias Gandure [7]: Day by day the cost of petroleum and diesel are increasing and by using these fuels, pollutants are releasing into atmosphere and the environment change is occurring. The comparative performance analysis of bio-diesel marula oil and petro diesel fuel on variable compression ratio engine. Engine which is powered with natural marula seed oil is giving accurate value in terms of engine performance, break torque and specific fuel consumption.

Paulo T. Nascimento Et-Al [8]: Due to increase in cost of petro diesel and increase in greenhouse effect there is need of using biofuels which won't release any pollutants into atmosphere. Petro bras, Exxos, BP and shell companies which are producing the biofuels. Petro bras and shell companies undertaking small projects.BP and Shell companies are doing large projects regarding production of biofuels.

METHOD AND EXPERIMENTATION: As with any engine and fuel combination, there are going to be issues of where NO_X s formed and how to reduce it. Below are some excerpts from various researchers utilizing different engines and blends of BD products: Adjustment of injection timing and engine operation temperature will result in these level [of nitrous oxides with biodiesel] being reduced below mineral diesel levels. Fueling with biodiesel/diesel fuel blends reduce particulate matter (PM), total hydrocarbons (THC) and carbon monoxide (CO) while increasing oxides of nitrogen (NO_X). Retarded fuel injection timing reduced NO_X emissions while maintaining the other emissions reductions. As concentration of biodiesel increased the oxides of nitrogen [NO_X] emissions increased. Retarding the timing was an effective way of reducing NO_X emissions when fueling with the biodiesel blends. Oxides of nitrogen emissions…can be successfully reduced below that of baseline diesel fuel by either retarding injection timing or replacing 20 percent of the baseline diesel fuel of the B20 blend with heavy alkylate. There are reliable proven methods for base lining or even reducing nitrous oxides produced when using biodiesel. They have certified emissions for the urban bus retrofit program with using this technology. This package included use of an oxidation catalyst to maximize particulate matter reductions and a timing change to give some PM reductions while reducing NO_X to baseline or even past baseline the best case was a 28% NO_X reduction with a 25% smoke reduction. Not even the researchers all agree on the best approach, but several items stand out. A combination of B100 (pure BD) cooled EGR (exhaust gas recirculation – cooled before reintroduction into the combustion chamber) and Catalytic converter to reduce smoke provides the seemingly best alternatives.

The cetane rating of diesel fuel is a measure of its ability to auto ignites quickly when it is injected into the compressed and heated air in the engine. For higher diesel engines, the cetane number required is about 50, for medium speed engines about 40, and for slow speed engines about 30. Cetane number is the most important single fuel property which effects the exhaust emission, noise and storability of a diesel engine. In general lower the cetane number higher is the hydrocarbon emissions and noise levels.

Calorific value of a fuel is the thermal energy released per unit quantity of the fuel. When the fuel burns completely products of combustion are cooled back to the initial temperature of the combustible mixture. When the products of combustion are cooled to about 25c, practically all the water vapor resulting from the combustion process is condensed. "The heating value so obtained is called the higher calorific value of the fuel. The lower or net calorific value is the heat released when water vapor in the products of combustion is not condensed and remains in the vapor form.

Calorific value of diesel oil	42000KJ/Kg
Calorific value of jatropha oil	44642KJ/Kg
-Calorific value of 10% jatropha oil + 90% diesel oil (B-10)	44642KJ/Kg
Calorific value of 20% jatropha oil + 80% diesel oil (B-20)	43904KJ/Kg
Calorific value of 30% jatropha oil + 70% diesel oil (B-30)	43166KJ/Kg
Calorific value of 40% jatropha oil + 60% diesel oil (B-40)	42428KJ/Kg
Calorific value of 50% jatropha oil + 50% diesel oil (B-50)	42660KJ/Kg

Calorific value of 60% jatropha oil + 40% diesel oil (B-60) 43585KJ/Kg

Performance Parameters:

Fuel air ratio:

It is the ratio of the mass of the fuel to the mass of the air in the fuel air mixture.

Fuel consumed per hour(Fch):

It is defined as the amount of fuel consumed per hour.

$$FCH = \frac{10 \times 3600 \times sp}{t \times 1000} \text{ kg/hr}$$

Here, sp=specific gravity; t= time (sec)

Brake power(B.P):

The power developed by an engine at the output shaft is called brake power and should be measured with the help of band brake dynamometer or hydraulic Dynamometer.

For a band brake dynamometer

$$\mathbf{B.P = \frac{2 \times \pi \times N \times T}{60000}} \text{ KW}$$

$$\mathbf{T = (S1\text{-}S2) \times R} \text{ kgf-m}$$

Here, N is speed in RPM; T is Torque in kgf-m; S1 and S2 are tensions on the brake drum and R is the radius of the drum in mts.

Indicated power(I.P):

I.P is the power developed in the cylinder due to the burning of the fuel

$$\mathbf{I.P = B.P + F.P}$$

B.P = Brake Power

F.P = Friction Power

Mechanical Efficiency:

$$\eta_{mech} = \frac{B.P}{I.P}$$

Break Thermal Efficiency

$$\eta_{B.Th} = \frac{B.P \times 3600}{FC \times CV}$$

Where FC = Fuel consumption Kg/hr.

CV = calorific value of fuel in K.cal/kg

Indicated Thermal Efficiency

$$\eta_{I.Th} = \frac{I.P \times 3600}{FC \times CV}$$

Break Mean Effective Pressure

$$\text{BMEP} = \frac{60000 \times B.P}{L\ A\ n\ K} \quad (N/m^2)$$

Here, L= length of the stroke (m), A= area of the piston (m^2), N = speed in revolutions per minute (rpm), n = Number of power strokes, N/2 for 4-stroke, N for 2-stroke engines, K = number of cylinders.

Indicated Mean Effective Pressure

$$\text{IMEP} = \frac{60000 \times I.P}{L\ A\ n\ K} \quad (N/m^2)$$

Basic Specific Fuel Consumption

$$B.S.F.C = \frac{F.C}{B.P} \quad (kg/Kw\text{-}hr)$$

Indicated Specific Fuel Consumption

$$I.S.F.C = \frac{F.C}{I.P} \quad (Kg/Kw\text{-}hr)$$

India's requirement of crude oil is more than its refining capacity and production hence, the balance is to be imported. India has gone for collaboration with Iran in the exploration and production of crude oil there leading to the production of oil in Rust am Oil fields and discovery of new oil field at Rakhash in the off shore areas of Persian Gulf. Crude oils are imported from Middle East countries. Russia, Indonesia etc. Existing oil refineries car TmeJ the present requirements of all produces except Kerosene and lubricating oils. Lubricating oils are made in the refineries at Digboi, Barauni, Madras and Haldia.

Table 1: Details of petroleum oil refineries located in India

Location	Year of commissioning	Refining capacity (Million Tones)
1. Digbio (Assam Oil Co.)	1899	0.525
2. Trombay. Bombay(Esso)	1954	3.500
3. Trombay, Bombay(Burmah-shell)	1955	5.000
4. Vishakhapatnam(Caltex)	1957	1.500
5. NUnmati near Guwahati	1962	0.850
6. Barauni in Bihar	1964	3.400
7. Koyali in Gujarat	1965	5.500
8. Cochin in Kerala	1966	3.300
9.Manali near Madras	1969	2.750
10. Haldia in west Bengal	1973	3.500
11. Bongaigon in Assam	----	1.000
12. Muthara in UP	----	6.000
13. Karnal in Haryana	----	3.000
14 Mangalore in Karnataka	----	6.000
	Total	45.825

Oil form seeds (e.g. pongamia and jatropha) can be converted to fuel commonly referred to as "Biodiesel" thorough a chemical process. NO engine modifications are necessary to use biodiesel in place of petroleum based diesel; Biodiesel can mixed with petroleum based diesel in any proportion. Biodiesel is registered as a fuel and fuel additive in U.S with the environmental protection agency (EPA) and is widely used in Europe. The use of biodiesel results in a substantial reduction of unburned hydrocarbon emission from biodiesel is nearly 50 percent less than that measured for diesel fuel. The fast point of biodiesel has been tested and reported by many sources it has been concluded that the fast point of biodiesel blends rises as the percentage of biodiesel increases. Therefore pure biodiesel or blends of biodiesel with petroleum diesel are safer to store, handle and use than conventional diesel fuel. In addition, it is essentially sulphur free and eliminates the emission of sulphur dioxide and sulphate aerosols.

In case of environmental conditions, Climate change is presently an important element of energy use and development. Biodiesel is considered "Climate Neutral" because all of the carbon dioxide released during consumption had been sequestered out or diesel fuel results in the emission of about 2.6 kilograms of CO_2. Therefore, the use of biodiesel will directly displace this amount of CO_2 when used. Combustion of biodiesel has been reported in a number of sources to have lower emission compared with petroleum diesel. Lower emission of SO_2, soot, carbon monoxide (CO), hydrocarbons (HC), poly aromatic hydrocarbons (PAH), and aromatics are presented in the following diagram. NOx emission from biodiesel is reported to range between plus or minus 10% as compared with petro diesel depending on engine combustion characteristics. Production of biodiesel involves growing the oil trees. Pressing the seeds into oil and processing the oil into biodiesel by transesterificaton. The proposed project envisages use of pongamia pinnata and jatropha curcas oils for production of biodiesel.

Fig 1: Jatropha Leaf

Fig 2: Jatropha Oil

The Botanic description of Jatropha: Jatropha curcas is a plant of Latin American origin which is now wide spread throughout aridn and tropical regions of the world. A member of the Euphorbiaceous family, it is a drought-resistant perennial, living up to 50 years and growing on marginal soils. A close relative to the castor plant, its oil has the same medical properties. It is significant to point out that the non-edible vegetable oil of jatropha curcas has the requisite potential of providing a promising and commercially viable alternative to diesel oil since it has desirable physicochemical and performance characteristics comparable to diesel.

Table 2: Chemical Analysis of Jatropha Curcas Oil as Follows

ITEM	VALUES
Acid value	38.20
Saponification value	195
Iodine value	101.7
Viscosity	40.4
Palmitic Acid%	4.2
Stearic acid %	6.9
Oleic acid %	43.1
Linoleic %	34.3
Other acids %	1.4

Property	Diesel	Jatropha
Viscosity(30°c)	3.6	52.5(5.5*)
Specific Gravity(15°c)	0.85	0.92
Carbon residue %	<0.15	0.64
Calorific value(MJ/kg)	40.44	37.38

Table 3: Comparison of properties of jatropha oil and standard specifications of diesel oil

Specification	Jatropha oil	Standard specification of Diesel oil
Specific gravity	0.9186	0.82/0.84
Flash point	240/110^{0}C	50^{0}C
Carbon Residue	0.64	0.15 Less
Cetane Value	51.0	50 up
Distillation Point	295^{0}C	350^{0}C
Kinematics Viscosity	50.73 Cs	2.7 cs.up
Sulphur%	0.13%	1.2%
Calorific Value	9,470 Kcal/Kg	10,170 Kcal/Kg
Pour Point	8^{0}C	10^{0}C Less
Colour	4.0	4 Less

Jatropha oil is non-edible oil and has a cetane number which is comparable to diesel and makes it an ideal alternative fuel as compared to other edible vegetable oils and indicates that no major modification in the diesel machine may be necessary. The initial flash point of jatropha oil is 110^{0}C as compared to 50^{0}C in case of diesel. Due to higher flash point jatropha oil has certain advantages over petroleum crude like greater safety during storage, handling and transport. However, the higher flash point may create only initial starting problem of the machine. Similarly higher viscosity of jatropha oil could pose problems of smooth flow of oil in the fuel supply Pipes and nozzles. However, it may be possible to overcome these defects by "esterification" of jatropha oil, which is a very effective way of overcoming the high viscosity and smoke emission of vegetable oils by forming their ethyl and methyl esters. Experiments conducted at Indian Institute of technology, Bombay indicate that CS kinematic viscosity of soybean oil could be reduced from 36.8 to 4.4 by this process and from 41.2 to 4.9 cs in case of peanut oil. The kinematics viscosity of jatropha oil is 51 and it may be possible to bring it down close to the viscosity of diesel to make it an ideal substitute to diesel either by evolving a suitable mix with ethanol or a suitable hexane.

RESULTS AND DISCUSSION: The following results were obtained with the blends listed below, which are tested on the 4-stroke C.I engine.

1. Pure diesel
2. B-10
3. B-20
4. B-30
5. B-40
6. B-50
7. B-60

The comparative graph for pure diesel and blended oils which is plotted between brake power and S.F.C reveals that pure diesel and blends of jatropha with diesel following same trend I.E.S.F.C decreases with increase in B.P. we can observe that the sfc for blends of jatropha are slightly more than the pure diesel. Although SFC is slightly more, in the view of foreign currency saving, usage of waste agricultural lands and low cost will make the jatropha as better one. Among all the blends of jatropha with diesel, SFC for B-30 oil is nearer to the pure diesel. The comparative graph for pure diesel and blended oils which is plotted between B.P and brake thermal efficiency reveals that pure diesel and blends of jatropha following the same trend i.e. brake thermal efficiency with increase in B.P. at a fixed B.P. Further thinning will improves combustion characteristics and this will leads to improve the brake thermal efficiency. Out of all the blends we have tested B-40 is having the nearer efficiency values to pure diesel. We can increase the break thermal efficiency by increasing the fuel injector pressure. The different performance parameters are calculated for different blends of jathropa oil and tabulated in the following tables.

Table 4: Diesel (100%)

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		92	81	76	62	49
3.	Fuel consumption (kg/hr)		0.3326	0.377	0.4026	0.4935	0.6244
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		2.5	3.105	3.71	4.315	4.92
6.	Mechanical Efficiency (%)		0	19.48	32.61	48.92	49.18
7.	Brake Thermal Efficiency (%)		0	13.75	25.76	31.52	33.22
8.	Indicated Thermal Efficiency (%)		64.42	70.59	78.98	74.49	67.53
9.	Brake Mean Effective Pressure (bar)		0	0.78	1.568	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		3.23	4.02	4.8	5.58	6.37
11.	Brake Specific Fuel Consumption (kg/kw-hr)		0	0.623	0.3327	0.2719	0.258
12.	Indicated Specific Fuel Consumption (kg/kw-hr)		0.133	0.121	0.1085	0.114	0.126

Table 5: Jathropa10

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		108	97	87	70	55
3.	Fuel consumption (kg/hr)		0.2856	0.318	0.3546	0.4407	0.5609
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		1.75	2.35	2.95	3.565	4.17
6.	Mechanical Efficiency (%)		0	25.5	40.6	50.9	58.03
7.	Brake Thermal Efficiency (%)		0	15.2	27.28	33.2	34.79
8.	Indicated Thermal Efficiency (%)		49.4	59.5	67.08	65.2	59.9
9.	Brake Mean Effective Pressure (bar)		0	0.77	1.55	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		2.26	3.04	3.8	4.6	5.4

11.	Brake Specific Fuel Consumption (kg/kw-hr)	0	0.53	0.29	0.24	0.23
12.	Indicated Specific Fuel Consumption (kg/kw-hr)	0.1632	0.135	0.12	0.1236	0.1345

Table 6: Jathropa20

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		110	97	85	71	54
3.	Fuel consumption (kg/hr)		0.2827	0.3206	0.3659	0.4380	0.578
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		2.5	3.105	3.71	4.316	4.921
6.	Mechanical Efficiency (%)		0	19.48	32.61	42.07	49.15
7.	Brake Thermal Efficiency (%)		0	15.47	27.11	33.99	34.34
8.	Indicated Thermal Efficiency (%)		72.5	79.41	83.1	80.79	69.81
9.	Brake Mean Effective Pressure (bar)		0	0.78	1.568	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		3.23	3.90	4.80	5.58	6.37
11.	Brake Specific Fuel Consumption (kg/kw-hr)		0	0.53	0.304	0.24	0.238
12.	Indicated Specific Fuel Consumption (kg/kw-hr)		0.113	0.103	0.098	0.101	0.117

Table 7: Jathropa30

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		109	98	88	69	52
3.	Fuel consumption (kg/hr)		0.2876	0.3199	0.3563	0.4544	0.603
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		1.55	2.15	2.76	3.36	3.97
6.	Mechanical Efficiency (%)		0	28.07	43.8	53.93	60.95
7.	Brake Thermal Efficiency (%)		0	15.77	28.32	33.31	33.47
8.	Indicated Thermal Efficiency (%)		44.94	56.18	64.6	61.76	54.9
9.	Brake Mean Effective Pressure (bar)		0	0.78	1.568	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		2.008	2.79	3.57	4.35	5.15

11.	Brake Specific Fuel Consumption (kg/kw-hr)	0	0.528	0.2944	0.25	0.2491
12.	Indicated Specific Fuel Consumption (kg/kw-hr)	0.1855	0.148	0.129	0.135	0.151

Table 8: Jathropa40

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		110	96	87	70	56
3.	Fuel consumption (kg/hr)		0.287	0.3292	0.3633	0.4115	0.5644
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		2	2.605	3.21	3.815	4.42
6.	Mechanical Efficiency (%)		0	23.22	37.73	47.57	54.75
7.	Brake Thermal Efficiency (%)		0	15.59	28.30	34.18	36.38
8.	Indicated Thermal Efficiency (%)		59.12	67.14	75.01	71.69	66.44
9.	Brake Mean Effective Pressure (bar)		0	0.78	1.568	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		2.59	3.37	4.16	4.94	5.72
11.	Brake Specific Fuel Consumption (kg/kw-hr)		0	0.544	0.299	0.248	0.2332
12.	Indicated Specific Fuel Consumption (kg/kw-hr)		0.1435	0.1263	0.1131	0.1183	0.1276

Table 9: Jathropa50

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		101	97	87	73	56
3.	Fuel consumption (kg/hr)		0.315	0.328	0.36	0.4364	0.5689
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		1.5	2.1	2.71	3.316	3.921
6.	Mechanical Efficiency (%)		0	28.5	44.6	54.6	61.7
7.	Brake Thermal Efficiency (%)		0	15.38	27.89	34.51	35.5
8.	Indicated Thermal Efficiency (%)		39.5	53.14	64.48	63.06	57.2
9.	Brake Mean Effective Pressure (bar)		0	0.77	1.55	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		1.94	2.72	3.51	4.29	5.0

11.	Brake Specific Fuel Consumption (kg/kw-hr)	0	0.54	0.29	0.24	0.23
12.	Indicated Specific Fuel Consumption (kg/kw-hr)	0.21	0.15	0.13	0.13	0.14

Table 10: Jathropa60

S.NO	DETAILS		1	2	3	4	5
1.	Tensions (kgf)	S1	0	5	10	15	20
		S2	0	2	4	6	8
2.	Time for 10 cc of fuel (sec)		108	94	82	68	52
3.	Fuel consumption (kg/hr)		0.2973	0.3416	0.3916	0.4722	0.6175
4.	Brake Power (Kw)		0	0.605	1.21	1.815	2.42
5.	Indicated Power (Kw)		2.55	3.155	3.76	4.365	4.97
6.	Mechanical Efficiency (%)		0	19.17	32.18	41.58	48.69
7.	Brake Thermal Efficiency (%)		0	14.7	25.49	31.71	32.33
8.	Indicated Thermal Efficiency (%)		71.19	76.65	79.69	76.72	66.80
9.	Brake Mean Effective Pressure (bar)		0	0.77	1.55	2.35	3.13
10.	Indicated Mean Effective Pressure (bar)		3.3	4.4	4.8	5.6	6.4
11.	Brake Specific Fuel Consumption (kg/kw-hr)		0	0.5646	0.3236	0.2601	0.255
12.	Indicated Specific Fuel Consumption (kg/kw-hr)		0.1165	0.1082	0.104	0.1081	0.1242

The graphs that are obtained from results and discussions are as follows:

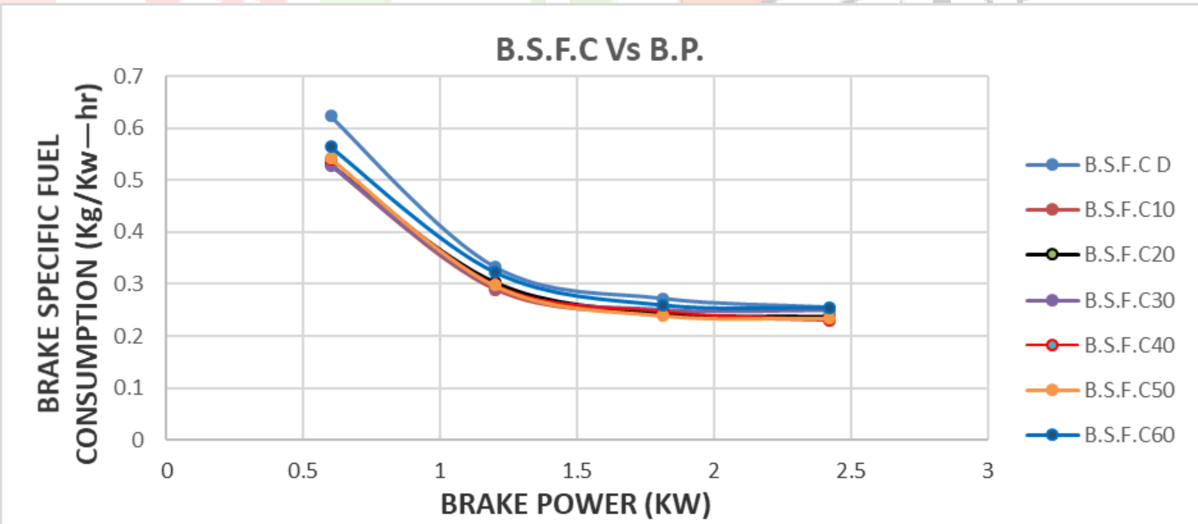

Fig 3. BSFC v/s BP

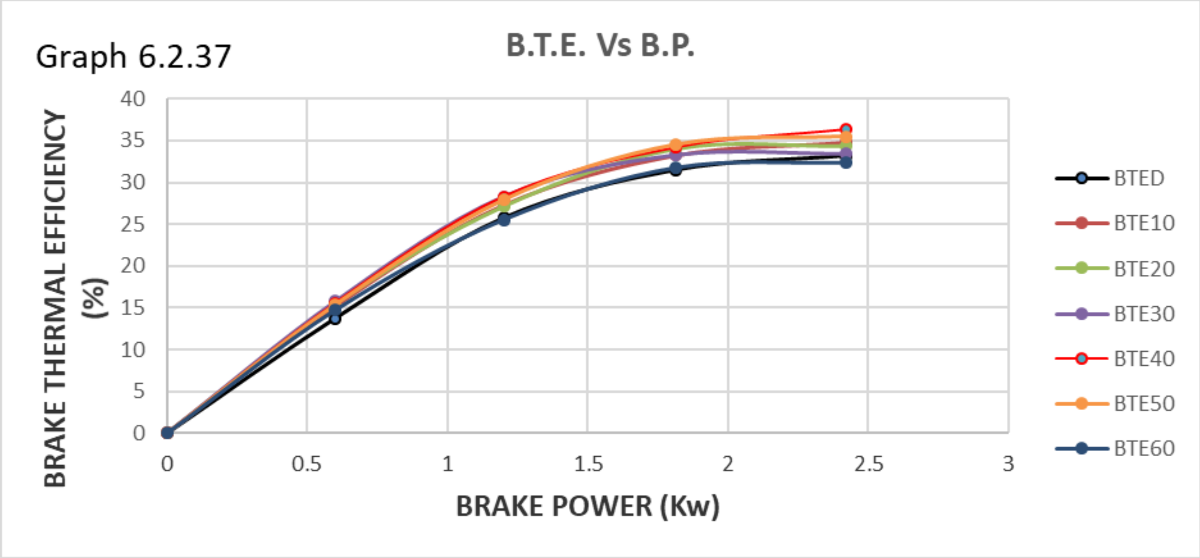

Fig 4. BTE v/s BP

CONCLUSION: All the blends of jatropha with diesel are showing the same trends in SFC and brake thermal efficiency with that of pure diesel so we can use them as alternatives to pure diesel without engine modifications and more over blends of jatropha with diesel are more echo friendly when compared to pure diesel and results are showing the same. Out of all the blends keeping the low SFC, high brake thermal efficiency and B-40 will be the best one. This can be used as substitute for pure diesel.

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