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Biodiesel Production from Jatropha oil and its Characterization on Diesel engine.

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1) ABSTRACT:

Biodiesel is an incompatible substitute that the research field is having these days in order to meet upcoming shortage of conventional fuel and environmental concern. For development of biodiesel the biological bodies those ranks at top most position suggest one such name of Jatropha carcus. The seeds of jatropha are crushed to give jatropha oil. The produced oil is been mixed with homogeneous catalyst in a definite proportion and then the trans-esterification process is been carried out for the mixture. Biodiesell(jatropha oil methyl ester) is obtained as output. The performance characteristic of obtained biodiesel is then compared to B20, CONVENTIONAL DIESELand E-DIESEL in a diesel engine..

The physical properties of extracted jatropha biodiesel such as flash point, fire point, cloud point, dynamic viscosity, density and pour point were found similar to conventional diesel due to addition of ethanol as stated in results. The smoke emission was also fairly reduced. The diesel engine was also not upgraded in design it was similar as for conventional diesel engine. The emission level and performance of different fuels had been observed under various characteristics such asThermal efficiency, BSFC, BSEC, Smoke density, HC, CO and Exhaust temperature. The performance result shows that jatropha biodiesel give best performance among all. Jatropha oil can be used as a resource to obtain biodiesel. The alkaline catalyzed trans-esterification is a promising area of research for the production of bio diesel in large scale

LIST OF ACRONYMS:

S.NO	ABBREVIATION	MEANING
1	**B20**	20% biodiesel blended with diesel.
2	**BE20**	20% ethanol blended with biodiesel.
3	**E-Diesel**	15% ethanol blended with diesel.
4	**BSFC**	Break specific fuel consumption.
5	**BSEC**	Break specific energy consumption.
6	**HC**	Hydrogen carbon.
7	**CO**	Carbon oxygen.
8	**MMT**	Metric mega tons.
9	**Ha.**	Hectare.
10	**EGA**	Enhanced graphic adaptor.
11	**ASTM**	American society for testing materials.

12	**FC**	Fuel consumption.
13	**BTE**	Break thermal energy.
14	**BSEC**	Break specific energy consumption.
15	**IOC**	Indian oil corporation.
16	**GHG**	Green house gas.
17	**GJ**	Giga joules.
18	**LCA**	Life cycle assessment.
19	**IR**	Indian railways.
20	**LCI**	Life cycle inventory.
21	**NEG**	Net energy gain.
22	**NER**	Net energy ratio.
23	**USD**	United states dollar.

2) OVERVIEW AND PROBLEM STATEMENT:

India is the seventh largest country in the world after Russia, Canada, China, USA, Brazil and Australia covering geographical area of 328.73 million ha., which constitutes 2.42 percent of earth's surface. India with 109 crore population is the second most populous nation of the world after China.

It ranks sixth in the world in terms of Its economy is projected to grow 8-9 percent over the next two decades and there will energy demand be a substantial increase in demand for oil to manage transportation and to meet various other energy needs. While India has significant of coal, it is relatively poor in oil and gas resources.

The annual requirement of petroleum products of the country is approx. 124 MMT. Our domestic production of crude oil and natural gas is approximate 34 million tones during 2006-07. The huge gap between demand and supply is met only by import. The net import burden was increased from USD 25.18 billion in 2004-05 to USD 37.17 billion in 2005-06 and taking into account the average price till now the net import bill for 2006-07 is USD 46.9billion. The increasing trend show one and half times increase annually and if the present increasing trend is continued. This is a matter of very serious concern for the country. The demand for diesel is likely to touch 66 million tones in 2011-12 and **80 million tones in 2013-15.** Contrary to the demand situation, the domestic supply is in position to cater to only about 30% of the total demand. Among various petroleum products, being developed from crude oil, diesel is being consumed maximum (i.e.80%) for transport of industrial and agricultural goods and operation of diesel driven tractors and pump sets in agricultural sector. The depletion vital fossil fuel resources and our of available over commitment to use the fossil fuels is likely to lead us to the energy crisis situation in the years to come. **.** It is estimated that 5%,10% and 20% blending of bio-diesel will require following quantity of bio-diesel considering 80.00 MMT demand during 2013-15.

TABLE1: COMPARISON OF PAST AND FUTURE DEMAND FOR DIESEL AND ITS FULLFILLMENT BY BIO-DIESEL.

YEAR	DIESEL DEMMAND MMT	BIO-DIESEL@5%	BIO-DIESEL@10%	BIO-DIESEL@20%
2006-2007	52.33	2.62	3.23	10.45.
2011-2012	66.90	3.35	6.69	13.38
2013-2015	80.00	4.00	8.00	16.00

To meet this challenging and horrible situation, our scientists have got success in identifying Jatropha as best alternative source of bio-diesel production.

Jatropha, a large soft-weeded deciduous shrub, is also known as Ratanjyot, Jamalgota, Chandrajyot etc. It is a wildly growing hardy plant, in arid and semi-arid regions of the country on degraded soils having low fertility and moisture. It can thrives well on stony, gravelly or shallow and even on calcareous soils having soil depth of about 2 feet. It can be cultivated successfully in the regions having scanty to heavy rainfall with annual rainfall ranges from 500-1200 mm.

The genus Jatropha belonging to Euphorbiaceae family of plant kingdom ,is a diploid with chromosome number (2n) 22, contains about 175 species in the world. The following 18 species are found mainly in India:

Jatrophacurcas,
Jatrophagossypifolia,
Jatropha glandulifera
Jatrophaheynei,
Jatrophaintegerrima,
Jatropha maheshwarii
Jatrophamultifida,
Jatrophamulendnifera,
Jatropha villosa
Jatrophanana,
Jatrophapodagrica,
Jatropha hastata
Jatrophatanjovurensis,
Jatrophahastate,
Jatropha macrofayala
Jatrophaacrocurcas,
Jatropha diyoka and
Jatropha sinera.

Out of above, *Jatropha curcas* gained prominence because of its added features like excellent adaptability to various habitats, larger fruits and seeds, high oil yielding, soil conservation capabilities, thriving well as live fence etc.

Analysis of jatropha curcus seed shows the following chemical compositions:
Moisture: 6.20%
Ash: 5.30%

2.1) Jatropha oil as best alternative to diesel:

Among various alternative sources,Jatropha is one of the best alternative for bio-diesel production due to its following characteristics:-

It can be grown in areas of low rainfall (500 mm per year) high rainfall irrigated areas and problematic soils with much

Protein: 18.00%
Fat: 38.00%
Carbohydrates: 17.00%
Fiber: 15.50%
watershed basis, on low fertility marginal, degraded, fallow, waste and other lands such as along the canals, roads, railway tracks, on borders of farmers' fields as a boundary fence or live hedge in the arid/semi-arid areas.

As such it can be used to reclaim wastelands in the forests and outside.Jatropha is not browsed by animals. Being rich in nitrogen, the seed cake is an excellent source of organic manure. One hectare of Jatropha plantation can produce 3 to 4 MT seed. Gestation period is two years.

Various parts of the plant have medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has honey production potential. Like all trees, Jatropha removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon. It is thus environment friendly.

higher yields.Jatropha is easy to establish, grows relatively quickly and is hardy.Jatropha lends itself to plantation with advantage on lands developed on

The country has 168 million ha. arable lands out of its 328.73 million ha. geographical area. There is about 63 million ha. wastelands in the country, out of which abou 40 million ha. area can be developed by undertaking plantations of Jatropha. The state-wise availability of wastelands and their exploitable potential under Jatropha plantation is as under:

TABLE2: STATE WISE AVAIBLITY OF LAND FOR JATROPHA TREE CULTIVATION.

S.NO	**States Available**	**wasteland (million ha.)**	**Exploitable potential of Jatropha plantation (million ha.)**
1	Andhra Pradesh	5.175	4.396
2	Arunachal Pradesh	1.832	0.997
3	Assam	2.001	1.456
4	Bihar/Jharkhand	2.009	1.860
5	Goa	0.061	0.04
6	Gujarat	4.302	2.871
7	Haryana	0.373	0.262
8	Himachal Pradesh	3.165	0
9	Karnataka	2.084	1.789
10	Kerala	0.145	0.10
12	Madhya Pradesh	6.971	6.720

13	Maharashtra	5.349	4.855
14	Manipur	1.295	1.262
15	Meghalaya	0.99	0.937
16	Mizoram	0.407	0.407
17	Punjab	0.233	0.106
18	Rajasthan	10.564	5.688
19	Tamil Nadu	2.301	1.795
20	Uttar Pradesh/ Uttranchal	3.877	1.214
21	West Bengal	0.517	0.285
22	Union Territories	0.057	0.055
	Grand Total	54.221	37.095

The above wasteland may be classified as gullied and ravenous, up-land with or without scrub, degradable land under plantation, pastures, grazing, mining industrial wasteland, hill slopes, fallow land, railway tracks, canal, field boundary and community waste land etc. The Jatropha can be grown in all above categories of wastelands with minimum care. This should be a major thrust area in making country independent in bio-fuel sector.

3) LITERATURE SURVEY:

India has not yet developed a comprehensive LCI database covering the production of basic materials, energy and fuels, transportation, and the ultimate disposal of goods based on India-specific conditions. As a result, many life cycle stages required inputs from better established European databases, particularly to obtain infrastructure impacts. The literature survey been conducted to find out what current situation do our country holds when compared to other in terms of development of bio-fuel. The researches been came into

1) Achtenetal. (2008) published a detailed literature review of available studies regarding Jatropha biodiesel production and use. The article gives an overview of the published data on Jatropha biodiesel production processes ranging from cultivation and oil extraction to biodiesel conversion and use. Data reported in the article serve to define many parameter values for the sensitivity analyses of this report. Based on the literature reviewed, the article concludes that the energy balance for Jatropha biodiesel is likely positive with the extent of the positive balance dependent on biodiesel for conventional diesel while identifying irrigation, fertilization, and transesterification as the processes with the greatest influence on net GHG emissions. The authors determined that the overall global warming potential for the production and use of 100% Jatropha biodiesel (B100) is 77% less than for conventional diesel based on another study by Prueksakorn and Gheewala (2006)

observations are stated as follows:

and a life cycle assessment by Tobin and Fulford (2005). However, neither of the two reviewed studies considered N_2O release from nitrogen fertilizer during cultivation, thereby underestimating, likely considerably, the GWP of Jatropha biodiesel production.

2) Prueksakorn and Gheewala (2008) conducted an LCA to evaluate the net energy gain (NEG) and net energy ratio (NER) of biodiesel produced from Jatropha cultivated in Thailand. This study excluded the impacts of facilities construction (i.e., infrastructure). NEG was defined as the difference between total energy outputs and total energy inputs while NER was calculated as the ratio of total energy outputs (including co-products energy content) to total energy inputs (including offsets such as avoided fertilizer production energy). The functional unit for this study was the production of one hectare of land over 20 years, and data was gathered from 14 research sites and 10 practical sites in Thailand. For average Jatropha cultivation and biodiesel production conditions, the authors calculated an NEG of 4,720 GJ/ha and an NER of 6.03 for biodiesel, plus co-products and a NER of 1.42 for biodiesel without consideration of co-products. The study was not designed to evaluate GHG emissions or to make comparisons to conventional diesel.

3) Reinhardt and colleagues (2007) conducted a screening LCA examining the advantages and disadvantages of Indian Jatropha biodiesel compared with conventional diesel. Biodiesel blends were apparently not evaluated. The study evaluated the environmental impact categories of consumption of energy resources, greenhouse gas (GHG) emissions, acidification, eutrophication, summer smog formation potential, and nitrous oxide ozone depletion potential. As a functional unit, the authors selected the use of Jatropha fruit harvested from one hectare of land in one year (i.e., land use efficiency). The diesel reference system was not clearly specified as to whether it represents diesel as sold in India or a world average stock. Data on many of the upstream processes were taken from the Institute for Energy and Environmental Research Heidelberg GmbH. The study evaluated Jatropha-based biodiesel production in the province of Bhavnagar, where poor soil conditions were assumed. The screening LCA evaluated biodiesel use to replace diesel in passenger cars and concluded that Jatropha biodiesel generally shows an energy balance savings of about 50%

(8 GJ of primary energy per hectare year) and also has a small greenhouse gas emission advantage of about 10% (approximately 100 kg CO_2 e per hectare year). The study also determined that Jatropha cultivation and processing made the greatest contribution to net GHG emissions, while the contribution of material transportation was minimal.

3.1) Application of bio-diesel:

- On December 31, 2002, IR used B5 in a test run of the prestigious Shatabdi Express as stated in figure.
- In May 2004, following the positive results of the initial laboratory and field trials, IR ran a test using B10 to operate the Jan-Shatabadi express for five days. IR observed no adverse effects in terms of hauling capacity, lube oil consumption, engine performance, or filter deposits. Additionally, fuel injection pumps and injector nozzles were found in satisfactory condition and free from any gum or resinous deposits.

Picture1.Shatabdi Express used in

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Picture3 Jatrophacurcas plant.

In 2003, IR signed a 15-year memorandum of understanding with the IOC to provide about 500 hectares of land to the IOC for the plantation of Jatropha to generate oil for processing into biodiesel (Ministry of Railways 2003). The IOC will direct the plantation and cultivation of Jatropha, oil extraction, and transesterification aspects of the project. One of the pilot project's goals is to develop better baseline data on plant

- Growth, seed yield, oil yield, and biodiesel production and performance. In total, IR seeks to have Jatropha planted on about 43,000 hectares of its land and will begin operating on with expansion up to 20% depending on field experience.
  blends of 1-5%

biodiesel trial

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- IR is also considering establishing a set of transesterification plants to produce biodiesel for use by its zonal railways. The Southern Railway, headquartered in Chennai, owns a transesterification plant and operates two diesel locomotives on B5.
- The Southeastern and Northeast Frontier Railways are also operating trains on B10. The Railway Board is requesting proposals for the supply of 50,000 kiloliters of biodiesel. If biodiesel blending is fully integrated into IR operations in the future, diesel fuel savings could range from 100 million liters per year for B5 to 400 million liters per year for B20.

3.2) CONSTRAINS IN JATROPHA CULTIVATION:

Jatropha curcas is a potential source of bio-diesel, however, it needs to be explored. The initiatives made to explore the possibility and potential of Jatropha have not yet reach to the final conclusion. The constraints are as hereunder:-

- The existing *Jatropha curcas* are giving yield in the areas where annual rainfall is above 500 MM
- Research trials are being conducted to test in different .
  - ✓ Possibility for Jatropha cultivation through inter-
- locations with various permutation-combination
- Almost all types of wastelands are suitable but soil depth should be more than 2feets.
- Non-availability of Minimum Support Price of produce of the farmers.
- No seed standard have been made so far to check the quality plantation.
- *The Jatropha curcas* can not tolerate frost and also the temperature below0'C.
- The productivity is comparatively low and not much economically beneficial to the farmers with the existing planting material.
- *Jatropha curcas* needs one or two life saving irrigation during summer season for better harvesting.

3.3) EFFORTS TO OVERCOME CONSTRAINS:

Superior quality planting material having high oil content and yield are being identified for further multiplication and production of quality planting material.

Picture2. Jatropha curcas seed.

cropping suitable for different states and agro-climatic conditions are being explored

- ✓ Model plantations are being developed on Agricultural Universities/Govt. seed farms in all the potential states to provide quality planting material to the farmers.
- ✓ The Minimum Support Price (MSP) of bio-diesel has been declared and is likely to be revised further, however, MSP of seed is still to be finalized.
- ✓ Seed standards are being made to bring Jatropha carcus into Seed Act so that Seed Law Enforcement can be made effective to ensure the quality plantation.

4) PRAPOSED METHOD:

Production Process:

Transesterification: Is the process of chemically reacting a fat or oil with an alcohol in a presence of a catalyst. Alcohol used is usually methanol or ethanol Catalyst is usually sodium hydroxide or potassium hydroxide.basically ethanol with KOH is used in this experiment. The main product of transesterification is biodiesel and the co-product is glycerine.

Separation: After transesterification, the biodiesel phase is separated from the glycerin phase; both undergo purification.

BIODIESEL PRODUCTION: In this study, the base catalyzed transesterification is selected as the process to make biodiesel from Jatropha oil. Transesterification-ion reaction is carried out in a batch reactor.

For transesterification process 500 ml of Jatropha oil is heated up to 70 C in a round bottom flask to drive off moisture and stirred vigorously. Ethanol having density0.791 g/cm³ is used. 2.5 gram of catalyst KOH is dissolved in Ethanol in bi molar ratio(6:1), in a separate vessel and was poured into round bottom flask while stirring the mixture continuously. The mixture was maintained at atmospheric pressure and 60°C for 60 minutes.

After completion of transesterification process, the mixture is allowed to settle under gravity for 24 hours in a separating funnel. The observation that was particularly recorded while performing the experiment was, if room temperature was maintained at 22 C then the settling down time was reduced to 18 hours which was earlier 24 hours. The products formed during transesterification were Jatropha oil methyl ester and Glycerin. The bottom layer consists of Glycerin, excess alcohol, catalyst, impurities and traces of un reacted oil. The upper layer consists of biodiesel, alcohol and some soap. The evaporation of water and alcohol gives 80-88 %pure glycerin, which can be sold as crude glycerin is distilled by simple distillation.

Jatropha methyl ester (biodiesel) is mixed, washed with hot distilled water to remove the un reacted alcohol; oil and catalyst and allowed to settle under gravity. The separated biodiesel is taken for characterization.

Ethanol had been blended with biodiesel mainly to find the possibility to use blended fuel with higher percentage of biodiesel in an un modified diesel engine. The obtained jatropha oil ethyl ester (boidiesel) is the been compared with blends of B20, E-diesel and diesel in a diesel engine whose specifications are discussed below. These comparing fuels were not prepared but were arranged from different labs. By using ethanol density, kinematic viscosity, low calorific value and aromatic fractions of blends decrease. Simultaneously, H/C ratio and oxygen content of blend are enhanced, which has favorable effect on the ignition and combustion of the blends.

BIODIESL PERFORMANCE ON DIESEL ENGINE : A single-cylinder, four stroke, water cooled, and naturally aspired direct injection diesel engine was used. The basic specification of the engine is shown in Table below. The combustion system of the diesel engine was a direct injection, medium swirl type. The specification of DC machine is presented in Table .The fuel consumption was measured with burette with 10ml volume and a stopwatch. The mass flow rate (kg/hr) was calculated from volumetric flow and fuel density.The engine specification along with the.dc machine are as under

The exhaust gas temperature was measured by using thermometer located downstream of exhaust valve. The tests were performed at unsteady state condition since some fluctuation may occur in engine operation especially in on-road conditions. Many of the studies of internal combustion engine have focused on steady- state performance and emission. However, the daily driving schedule of automotive and truck engine is inherently related to unsteady operation, whereas the most critical condition encountered by engine are met during transient that making the studies of transient engine operation an important scientific objective. Similarly, a work results, the literature indicated that depending on engine load, the pressure variation in the cylinder exhibit different type of behavior. The tests were performed at unsteady state test the fuels were tested in random order and each test repeated 3 times. The results of 3 repetitions were averaged to decrease the uncertainty. By mean of the instrument ambient temperature (^{o}C), CO (%), HC (ppm) is measured and calculated.

Items	Specification
Model	Kirloskar Av1
No of cylinder	1
Bore	8cm
Stroke	11cm
Power	5hp
Compression ratio	16.5:1
Speed	1500 rpm

TABLE3: **Basic technical specification of the test engine.**

Items	Specification
Model	Samson D.C machine
Volt	150
Power	4.6 KW
Current	40 Amp
Speed	1500 rpm

TABLE4: **Technical specification of DC machine**

Items	Specification
Company	AVL DIGAS 444
CO	0 - 10%
HC	0 –20000(ppm)

TABLE5: **Technical specification of EGA.**

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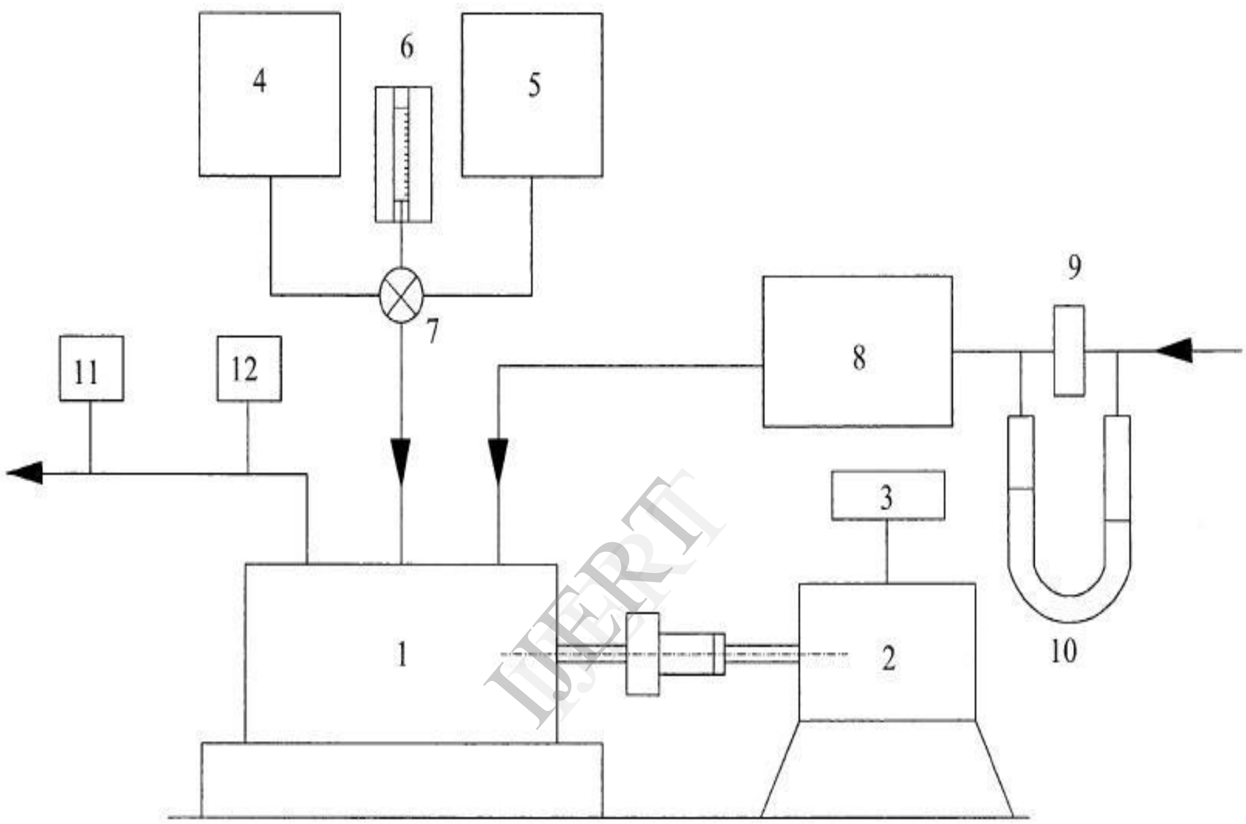
Discussed below:



Picture4. Schematics diagram of experimental setup.

(1) Engine; (2) Electrical load bank; (3) voltmeter, ammeter; (4) Diesel fuel tank; (5) Biodiesel fuel tank; (6) Burette; (7) Two way valve; (8) Air box; (9) Orifice plate; (10) U tube manometer; (11) Smoke meter; (12) EGA.

The production of jatropha oil ethyl ester ie, biodiesel from jatropha seeds and performance characteristic of this oil when compared to other blends and diesel had been explained in a brief manner as stated above and the result that were observed are discussed as under:

5) EXPERIMENTAL DATA ANALYSIS AND RESULT:

Biodiesel Characterization: The specific gravity reduces after transesterification viscosity from 57 to 4.73 centistokes, which is acceptable as per ASTM norms for Biodiesel. Flash point and fire point are important temperatures specified for safety during transport, storage and handling. The flash point and fire point of biodiesel was found to be 128°C and 136°C respectively. Flash point of Jatropha oil decreases after transesterification, which shows that its volatile characteristics had improved and it is also safe to handle,

Higher density means more mass of fuel per unit volume for vegetable compared to diesel oil. The higher mass of fuel would give higher energy available for work output per unit volume.

Higher viscosity is a major problem in using vegetable oil as fuel for diesel engines. Cloud and pour point are criterion used for low temperature performance of fuel. The cloud point for Diesel is4 C which is very lo w and the fuel performs satisfactorily even in cold climatic conditions. The higher cloud point can affect the engine performance and emission adversely under cold climatic conditions. The pour point for Diesel is -4 C.

In general higher pour point often limits their use as fuels for Diesel engines in cold climatic conditions. When the ambient temperature is below the pour point of the oil, wax precipitates in the vegetable oils and they loose their flow characteristics, wax can block the filters and fuel supply line. Under these condition fuel cannot be pumped through the injector. In India, ambient temperatures can go down to 0 C in winters. Fuels with flash point above 66 C are considered as safe fuel.

It is important to emphasize that the blend fuel and the diesel fuel that was used as reference were evaluated under the same conditions, analyzing the performance and emission of the fuel in varying proportion of load.

The fuel consumption was obtained at B20, BE20, E- diesel & diesel fuel. The engine fuel consumption for BE20 & Diesel fuel is almost lower than that of B20; E- diesel its mainly shown in fig 1.

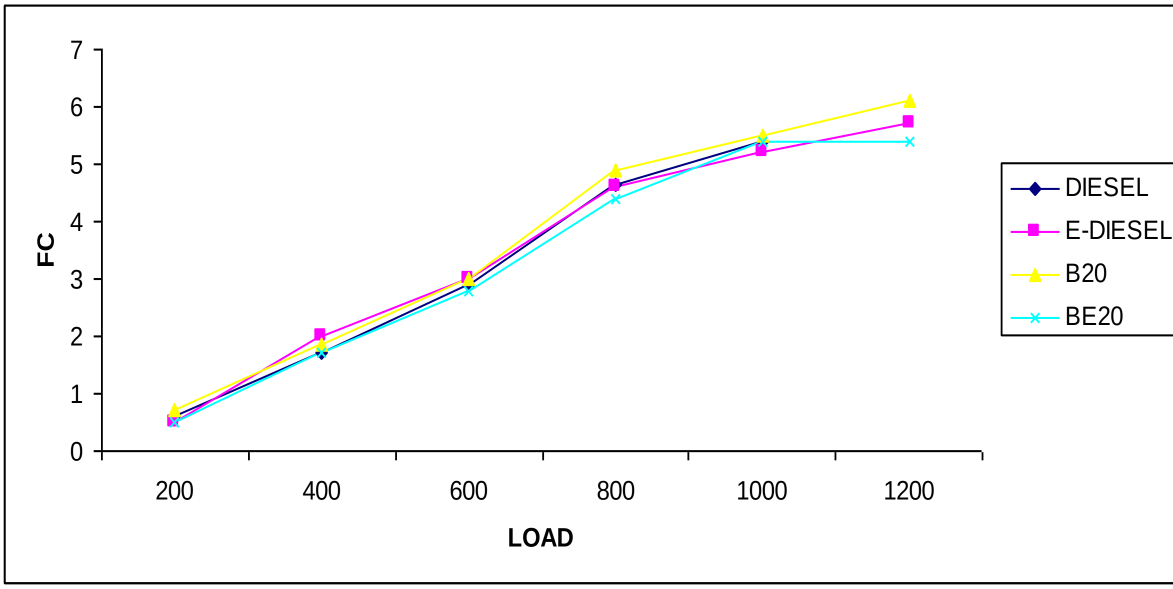


Fig 1 The FC variation at different Brake power for BE20, B20, E-diesel and DF

BE20 fuel operation showed lower BSFC, than expected, as shown in fig 2 especially at higher loads. Higher BSFC was observed when running the engine with B20 fuel. Average brake-specific fuel consumption for usage of B20 was 39.6% which higher that of diesel fuel and 34.8% higher than that of BE20 and for E-Diesel it was 37.8%. The fuel viscosity had a great influence on brake specific fuel consumption that led to almost similar BSFC result for BE20 and DF which shown in fig 2.

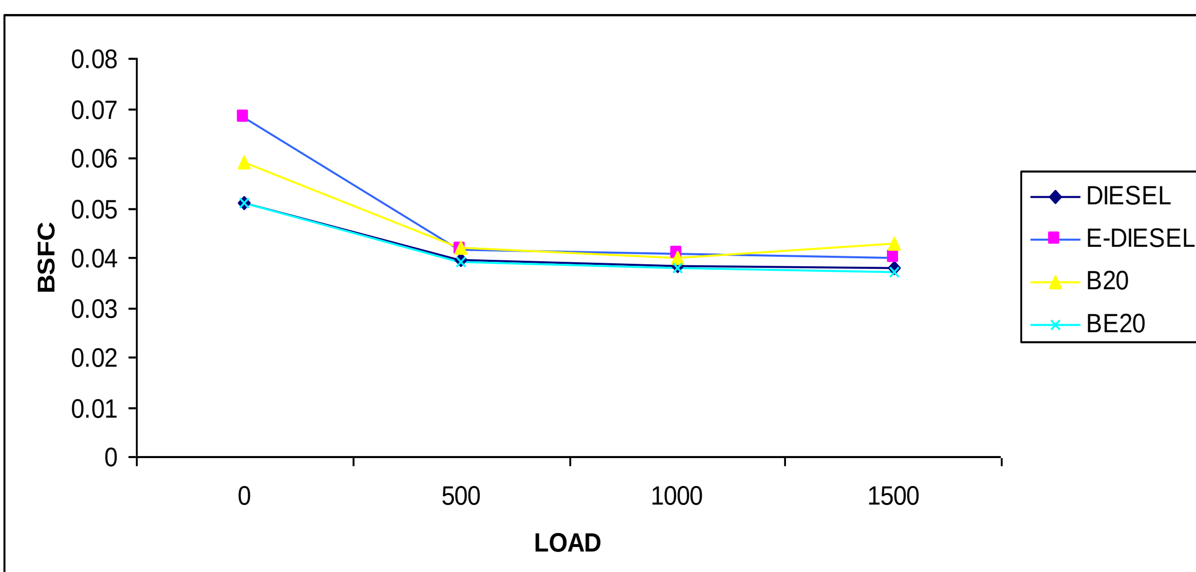


Fig 2 The BSFC variation with different load for BE20, B20, E- diesel, DF

Fig 3 shows the comparison of the brake thermal efficiency with load tested fuels. It can be observed from figure that the brake thermal efficiency was 24.96% for BE20, while those of DF, B20 & E diesel were 23.24%, 23.51% & 24.4% respectively. The brake thermal efficiency of B20 & diesel was lower compared to E- diesel and BE20. This may due to the lower heating value and inferior combustion of biodiesel & diesel. Besides, the brake thermal efficiency of BE20 is higher than that of standard diesel especially at higher load. The possible reason for improved brake thermal efficiency may be more complete combustion, and additional lubricity of biodiesel that contained in BE20.

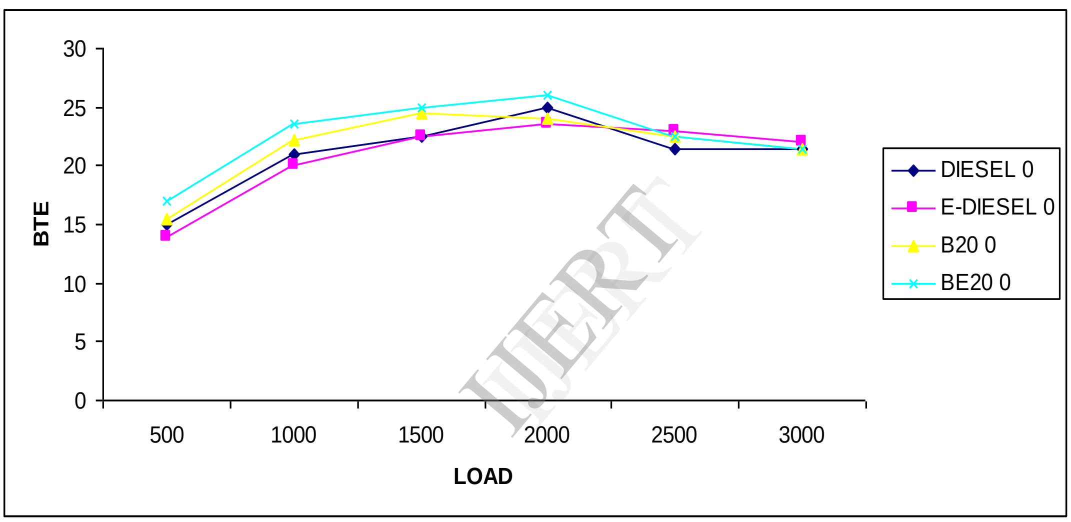


Fig 3 Variation of Brake thermal efficiency with different load for BE20, B20, E-diesel & Diesel.

Fig 4 depicts that, the brake specific energy consumption decrease by 25-30% approximately with increase in load. This reserve trend was observed due to lower calorific value with different biodiesels.

The brake specific energy consumption (BSEC) mainly shows energy consumption ofdifferent fuels. Lower the BSEC lower will the, fue since fuel consumption and BSEC should be lower of any fuels.

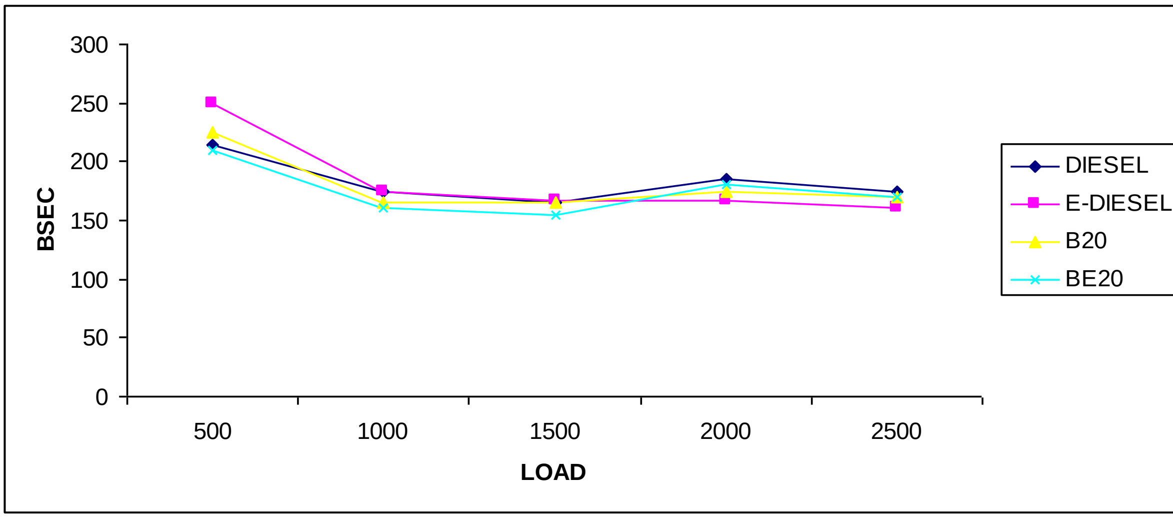


Fig 4 show BSEC vs LOAD

The exhaust gas temperature with BE20 was higher when compared to those of diesel and B20 fuel, E- diesel fuels (Fig 5). In Fig 5, BE20 shows higher temperature different at each load of the engine than the other fuels (B20, EDiesel & DF). The main reason for large difference between BE20 and Diesel fuel may be improved combustion of BE20 thanks to the ethanol added to biodiesel. An-other reason may be shortened combustion period of BE20 with increased flame velocity. Beside, the temperature for diesel & B20 is quite similar. The exhaust temperature of E- diesel is higher than that of B20 and diesel.

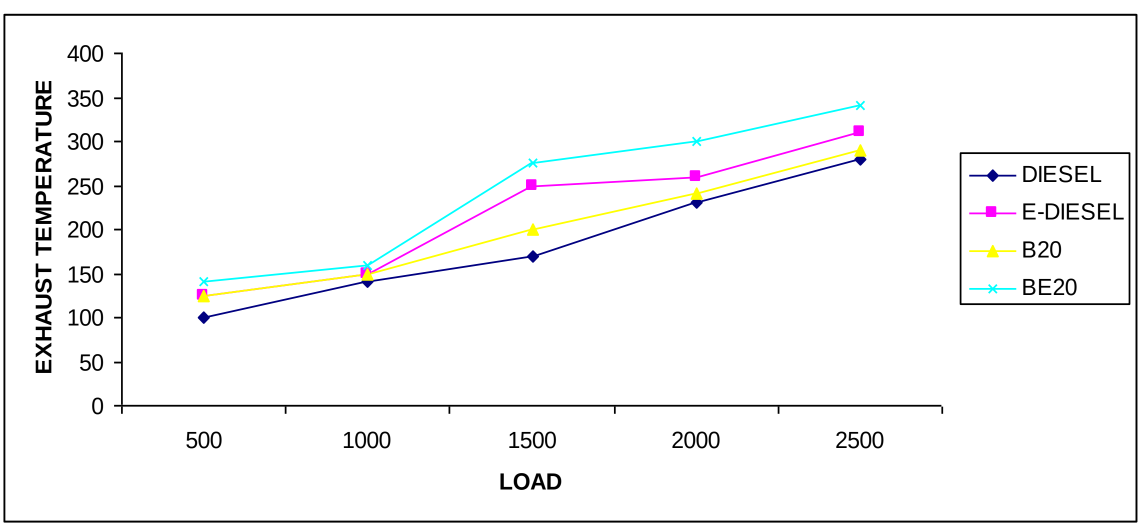


Fig 5 Shows variation of exhaust temperature of different fuels.

Fig 6 shows that CO emission by B20, E-diesel, BE20 & diesel. The biodiesel blends, is lower than the ones for the corresponding diesel fuel case. This can be explained by the enrichment of oxygen owing to ethanol and biodiesel addition, in which an increase in the proportion of oxygen will promote the future oxidation of CO during the engine exhaust process.

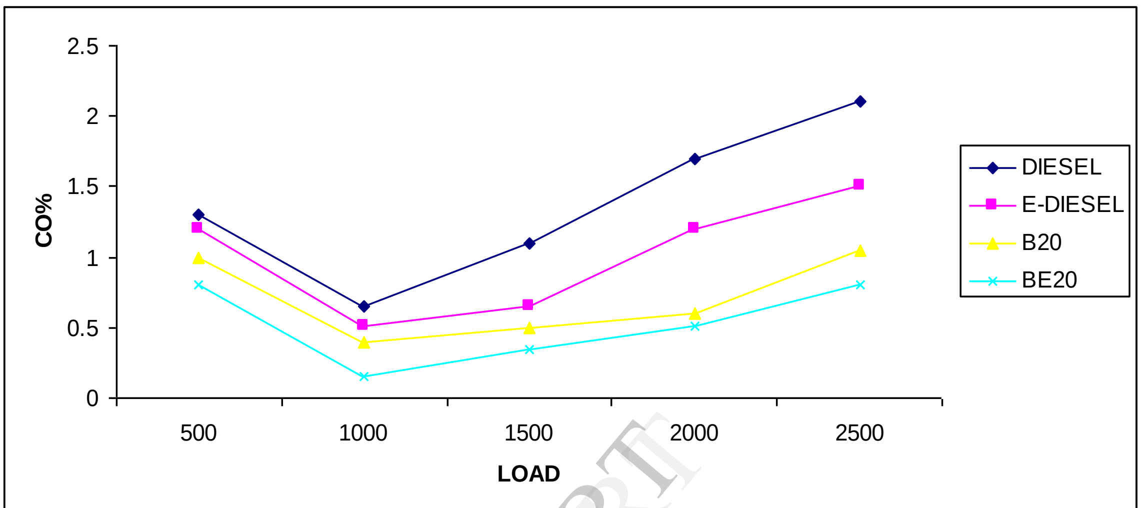


***Fig 6 shows the variation of CO emission of different fuels*.**

Fig 7 shows the HC emission of different fuels. It mainly shows that the HC emission of BE20 is lower than that of any fuels since exhaust temperature of BE20 is higher this mainly effect HC emission of fuel. Since diesel shows higher amount of HC emission because it has lower exhaust temperature.

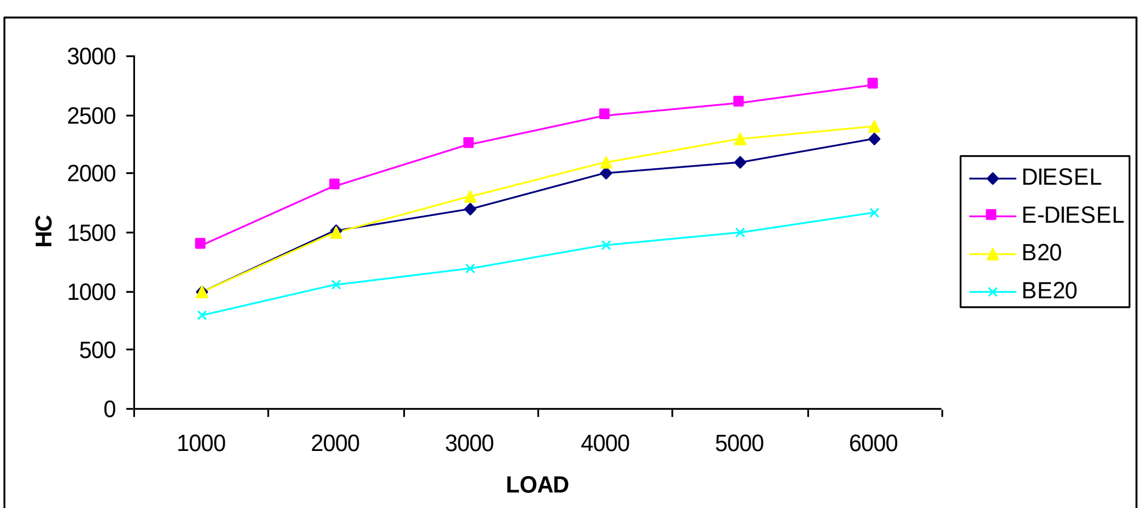


***Fig 7 shows HC variation of different fuels*.**

6) CONCLUSION:

In the current investigation, it has confirmed that Jatropha oil may be used as resource to obtain biodiesel. The experimental result shows that alkaline catalyzed transesterification is a promisin area of research for the production of biodiesel in large scale.The best combination of the parameters was found as 6:1 molar ratio of Methanol to oil, 0.92% KOH catalyst, 60 C reaction temperature and 60 minutes of reaction time The viscosity of reduces substantially.
Blends of biodiesel and ethanol fuel can be used as alternative fuels in convectional diesel engine without any changes.

- Fuel consumption of BE20 is lower than other fuel mainly B20, E- diesel, diesel due the ethanol being used as additives in biodiesel which mainly lower the fuel consumption rates
- BSFC was lower for BE20 than any other fuels especially lower than E diesel and B20 and was same than that of diesel fuel.
- BSEC for BE20 lower due calorific value is almost same with diesel fuels.
- Brake thermal efficiency of BE20 is higher than any other fuels specially. Diesel has lower BTE than any other fuels
- The highest percentage of exhaust temperature was obtained with blend of BE20 which is helpful in proper combustion.
- The CO percentage of BE20, B20& E-diesel is lower than that of diesel. This may result in lower CO emission with blend of biodiesel.
- The HC emission mainly depends on exhaust temperature of any fuel since BE20 has lower HC emission.
- The smoke density of BE20, B20 is lower than E diesel & diesel due to the lower HC emission.

The main conclusion derived by this research is that using ethanol with biodiesel can potentially remove serious problem revealed with the use of high percentage of biodiesel in operation of unmodified diesel engine. The exhaust emission of BE20 and other biodiesel is reduced and the fuel blend BE20 is about 90% renewable and emission free.

8) References:

- Zimbabwe Biomass News Plant oil Zimbabwe sustainable fuel for th e future, BUN-Zimbabwe, P/Bas 7768, Causeway, Zimbabwe **1(2),(1996).**

- Heller J., Physic nut, Jatropha carcass promoting the conservation and use of underutilized and neglected crops. International Plant Genetic Resources Institute (IPGRI), Rome, Italy, **(1996).**
- Barn Wall B.K. and Shama M.P., Prospects of Biodiesel Production from Vegetable oils in India, I, , 9, 363-378, **(2005).**
- Lim D.G., Soares V. C.D., Ribeiro E.B., Carvalho D.A., Cardoss E.C.V., Rassi F.C., Mundim K.C., Rubin J.C., and Suarez P.A.Z., Diesel-like fuel obtained by Pyrolysis of Vegetable oil, *Journal of Analytical and Applied Pyrolysis 71*, 987-998 **(2004).**
- Avinash Kumar Agarwal, Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines .
- C.D. Rakopoulos, K.A. Antonopoulos, D.T. Hountalas, E.G. Giakoumis, Comparative performance and emissions study of a direct injection diesel engine using blends of diesel fuel with vegetable oils or bio-diesels of various origins, Energy Conversion and Management (2006) .
- A.C. Hansen, Q. Zhang, P.W.L. Lyne, Ethanol–diesel fuel blends –a review, Bioresource Technology 96 (2005).
- Ramadhas A.S., Jayaraj S. and Muraleedharan, C., Use of Vegetable in I.C. Engines-Review, *Renewable energy, 29,* 727-742**, (2004).**
- P.M. Merritt, V. Ulmet, R.L. McCormick, W.E. Mitchell, K.J. Baumgard, Regulated and unregulated exhaust emissions comparison for three Tier II non-road diesel engines operating on ethanol–diesel blends, SAE Technical Paper 01(2005) .
- E. Ecklund, R.L. Bechtold, T.J. Timbario, P.W. Mc Callum, State of the art report on the use of alcohols in diesel engines, SAE Transactions 840118 (1984) .
- A.K. Agarwal, K. Rajamanoharan, Experimental investigations of performance and emissions of Karanja oil and its blends in a single cylinder agricultural diesel engine, Applied Energy 86 (2009).
- Srivastava A, Prasad R. Triglycerides-based diesel fuels. Renew Sustain Energy Rev 2000 .
- Agarwal D, Agarwal AK. Performance and emission characteristics of a Jatropha oil (preheated and blends) in a direct injection compression ignition engine. Int J Appl Therm Eng 2007.
- Altin R., Cetinkaya S. and yu cesu H.S., The Potential of using Vegetable oil fuels as fuel in Diesel engines, *Energy Conservation and Management 42,* 529-538, **(2001).**
- Demiras A., A Direct Route to the calculation of the Heating values of liquid fuels by using their density and viscosity measurement , *Energy Conservation and Management*41, 1609-1614 **(2000).**