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Investigation on Emission characteristics of a Twin Cylinder Diesel Engine using Jatropha oil methyl ester with Di-Methyl Carbonate

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***Abstract:*-- A remarkable growth is observed in the automobile as well as industrial sectors and accordingly the requirement for the fossil fuels is also increasing. As a result, the amount of fossil fuels available is decreasing drastically. It is well know that modern world depends mostly on energy produced from different energy sources, because of their various uses. Most of the energy sources are fossil fuels which are getting exhausted. Therefore, many scientists from different parts of the globe are carrying out research to find an alternative source in order to replace the existing one. Biodiesel can replace the present energy crisis and further help in reducing global warming. It is mainly produced from edible and non-edible oils. Non-edible oils when blended with diesel give rise to biofuels which have exhibited a remarkable growth in the automobile industries because of their environment friendly and lubricating nature. The present paper elaborates about the emission characteristics of an agricultural diesel engine utilizing jatropha oil methyl ester with diesel blends (B10, B20 and B30). All the emission values were noted and plotted in the graph against loads varying at 0%, 20%, 40%, 60%, 80%, 100%. The results depict that BD20 is the blend which shows the less tendency towards emissions like CO, CO_2, HC, while there is a slight increment in both NOx and smoke emission in comparison to other test fuel blends which gives a conclusion that B20 is a best alternative fuel capable of replacing current petroleum diesel fuels to reduce the engine emissions..**

1. INTRODUCTION

More than 90% of the automobiles and industrial equipment's depends on the petroleum products. They play an important role and form a crucial asset in determining the competency of a nation in this fast progressing world. But the competency has led to the continuous exploitation of conventional fuels which directly led to energy crisis and this has become a major concerning factor for both the developing as well as developed countries[1]. The shortage of conventional fuels gave rise to the idea of non-conventional fuels which are degradable, eco-friendly and one among them is biodiesel. Biofuels are fuels which are derived from biomass, they can be in solid, liquid and gaseous form. Biomass can be used directly for heating or power or it can be processed to get the maximum benefit from it. Biofuel can be produced from any carbonaceous material [2].Many different plant derived materials are used for biofuel manufacturing. Ethanol is also a biofuel because it is made from corm. Biodiesel is vehicle fuel made from vegetable oil. Biodiesel has special characteristics like it is renewable, biodegradable and toxic in nature. It is readily available in nature which can be portable having inherent lubricity with high flash point and cetane ignition rating along with lesser emission rates than the pure diesel. These advantages of Biodiesel made it an ideal fuel in the nature. The main reason why the biodiesel is used in worldwide is the wide range of its feedstocks which makes its promotion to the best alternative fuel [3]. Globally, there are more than 350 crops identified as feedstock for the biodiesel industry which alone represents 75% of the overall biodiesel production cost [1-2]. So, it is important to select a cheapest form of feedstock which leads for the low production cost of biodiesel. Biodiesel is produced from both edible and non-edible oils. The developing countries like India uses non edible oils for the production of biodiesel because edible oils are eatable and they form a major part of diet.

2. INTRODUCTION TO JATROPHA

Jatropha plant belongs to the family of "Euphorbiaceae" and genus of "Jatropha L". Cultivation of Jatropha is uncomplicated it grows in both subtropical and tropical regions. Jatropha is a good crop that can be obtained with a little effort. Jatropha Curcas is one of the best oil seed plants for the production of biodiesel. Seeds that are produced from Jatropha contain 37% of oil[4]. The oil that is produced can be directly used for combustion without refining. The oil that is produced from Jatropha is highly toxic. Generally Jatropha plant grows between 3-5 meters in height, it can grow up to 8-10meters of height under favorable conditions. The oil seed that is produced by Jatropha plant acts as an energy source in the form of biodiesel. The major advantage of the Jatropha is it can be grown in poor soils, leaving the rich soils in the cultivation of other consumable goods [5]

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Tab 1. Energy capabilities of common types of fuel

CF	Specific energy (MJ/kg)	AFR stoich.	FAR stoich.	Energy @ λ=1 (MJ /kg(Air))
Hydrogen	142	34.3 : 1	0.029 : 1	4.140
LPG	46.4	17.2 : 1	0.058 : 1	2.698
Kerosene	46	15.6 : 1	0.064 : 1	2.949
Gasoline	46.4	14.7 : 1	0.068 : 1	3.156
Diesel	48	14.5 : 1	0.069 : 1	3.310
Ethanol	26.4	9 : 1	0.111 : 1	2.933
Methanol	19.7	6.47 : 1	0.155 : 1	3.045
Nitromethane	11.63	1.7 : 1	0.588 : 1	6.841

1 MJ ≈ 0.28 kWh ≈ 0.37HPh

As we can see from the above chart that the main source of energy in India is fossil fuels which is not good for the environment. So we require alternative fuels.

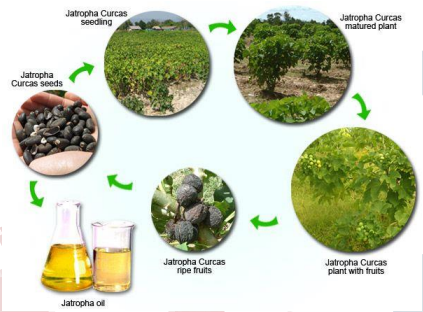

Fig 1. Life cycle of jatropha Curcas

3. SCOPE OF JATROPHA CULTIVATION

Due to high demand cultivation of Jatropha is viable and it does not replace traditional crops. This crop is best in the areas where annual rainfall is less and in barren lands, so this crop is best hope for farmers. For agricultural crops, this Jatropha can be used as live fencing as no livestock will eat this jatropha plant [6]. When it comes to Jatropha, every part of this plant can be used such as a raw material for pharmaceutical and for cosmetic industries; it can also be used as input for traditional medicine [1]. Jatropha provides good economic life to farmers, when it is cultivated in poor soils, barren lands and drought areas.

4. SOIL AND CLIMATE REQUIREMENT FOR CULTIVATION OF JATROPHA.

It is the tropical species, it grows good in subtropical conditions. This crop can grow in extreme temperature but logging of water does not permit to grow [7]. Jatropha can be grown even in acid and alkaline soils, sandy and gravel. It is cultivated in the soils having pH 5.4 to pH 8.5. It can even thrive in poorest soils that are present on stones. It grows even in crevices and cracks of rocks on all types of soils except to water flow. If there is rise in water flow and that water engulf the major root system to some extent of time the plant will die[8].

Fig 2. Jatropha plantation

5. ADVANTAGES OF JATROPHA

- Jatropha is mainly used in production of biodiesel.
- It can be grown in poor soils, waste lands
- Jatropha is suitable for preventing the soil erosion
- Fertility of soil increases throughout the lifecycle
- This plant can also be used for medical purposes

6. DISADVANTAGES OF JATROPHA SEEDS

- Jatropha compounds are highly toxic
- The Jatropha plant cannot produce the nut, if there is too little water.

Fig 3. Jatropha seeds

7. PRODUCTION OF JATROPHA OIL BIODIESEL

7.1 Biodiesel Production

Biodiesel is made by reacting vegetable oil or animal fat with an alcohol (methanol or ethanol) and a catalyst. This process separates the glycerin from oil or fat. Thus resulting in biodiesel which is thinner than the original oil or fat and works better in diesel engine. Biodiesel production is the

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method of producing the biofuel, biodiesel, through the chemical reactions such as transesterification and esterification. This involves vegetable or animal fats and oils being reacted with short chain alcohols (typically methanol or ethanol)[9]. The alcohols used should be of low relative molecular mass, ethanol is most commonly used because of its low cost, however greater conversion into biodiesel can be done using methanol. The method of production is base catalyzed transesterification, this process is chosen because it consumes less time and also the cost of catalyst is low. This process is cheaper than the acid esterification[10]. However alkaline catalyst has the disadvantage of high sensitivity to both water and fatty acid present within the oil.

Tab 2. Process parameters[1]

SI No	Process parameters	Description
1	Sample oil used	1000 ml Jatropha oil
2	Methanol used	200ml/kg of alcohol
3	Process selected	Alkali catalyzed transesterification process
4	Catalyst used (KOH)	0.5-1% per kg of oil
5	Reaction temperature	52-55^{0}C
6	Reaction time	1.5-2 hours
7	Settling time	8-10 hours
8	Water wash	3-4 times(40min)
9	Speed of Stirrer	500rpm

7.2 Transesterification

It is a process of manufacturing of Biofuel by adding alcohol. Transesterification is the process of interchanging R' of an ester to the organic group R' of an alcohol [8]. This transesterification process is catalyzed by inclusion of acid or base catalyst [4]. Methanol and Ethanol are the majorly used in the process of transesterification, among these two alcohols methanol is most extensively used because of its low price and physicochemical advantages with triglycerides. 3:1 ratio of alcohol to triglycerides is needed for complete transesterification process [9].

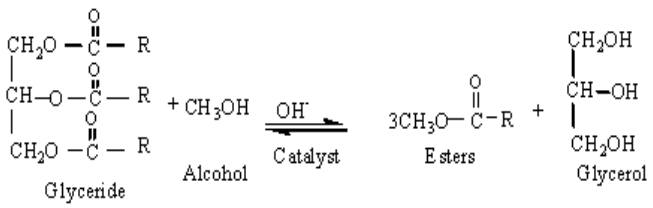

Fig.4 Transesterification Reaction [1]

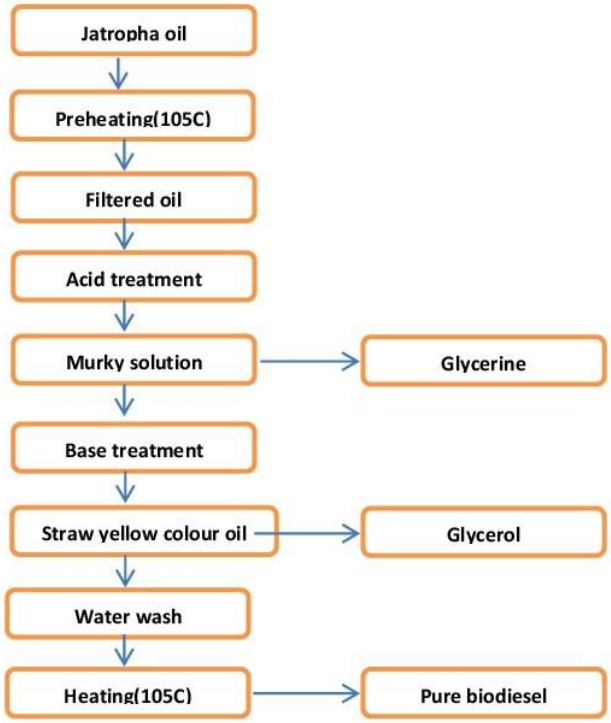

Fig 5. Methadology of prepararion of Biodiesel

Tab 3. Physical Characteristics of Biodiesel

Specific gravity	0.88
Kinematic viscosity at 40 degree celcius	4.0 to 0.6
Cetane number	48 to 65
Higher heating value, Btu/gal	"127,960
Lower heating value,Btu/gal	119,550
Density, lb/gal at 15.5 deg celcius	7.3
Carbon, wt%	77
Hydrogen, wt%	12
Oxygen, by diff. Wt%	11
Boiling point, deg celcuis	315-350
Flash point, deg celcius	100-170
Sulfur, wt%	0.0 to 0.0015
Cloud point, deg celcius	-3 to 15
Pour point, deg celcius	-5 to 10

8. EMISSIONS OF JATROPHA OIL BIODIESEL IN ENGINE.

For every action there is an equal and opposite reaction similarly for an engine, if a fuel is injected into the engine then there will be equal and opposite emissions and exhaust gases as the output reaction which is harmful for environment and human life.

After manufacturing of Jatropha Bio Oil then it is blended in different ratios as, JOBD10, JOBD20, JOBD30 .All these

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blends including pure standard diesel Oil(PD) is injected into the engine to experiment on the emission that are caused by Jatropha Oil Bio Diesel [10].

8.1 Co vs BP

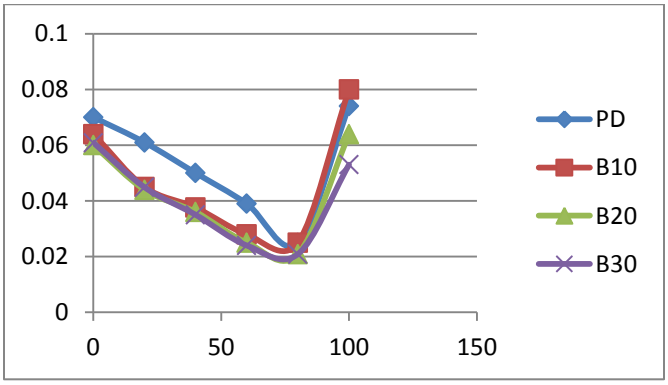

Fig 6. CO Vs BP

Due to incomplete combustion in the engine Carbon monoxide (CO) was formed in the engine which is colorless, odorless, poisonous gas. In the engine if there is poor atomization or uneven distribution of fuel in the combustion chamber, then some fuels are left un burned and some carbons atoms ends up with CO. At 0 load of an engine, the emission of CO is 0.06ppm for JOBD20, 0.0609ppm for JOBD30, 0.064ppm for JOBD10, 0.07ppm for Pure Diesel. Similarly at 100% load of an engine, the emission of CO is 0.053ppm for JOBD30, 0.0639ppm for JOBD20, 0.074ppm for Pure Diesel, 0.08ppm for JOBD10 [11]. We can observe that Initially CO emissions are almost constant. As the engine load was increasing emission also continued to increase, after 80% of engine load there exists some incomplete combustion of the excess fuel that is injected into the combustion chamber because of lower air fuel ratio because of that the CO emissions have started increasing at high loads [12].

8.2 NOx vs BP

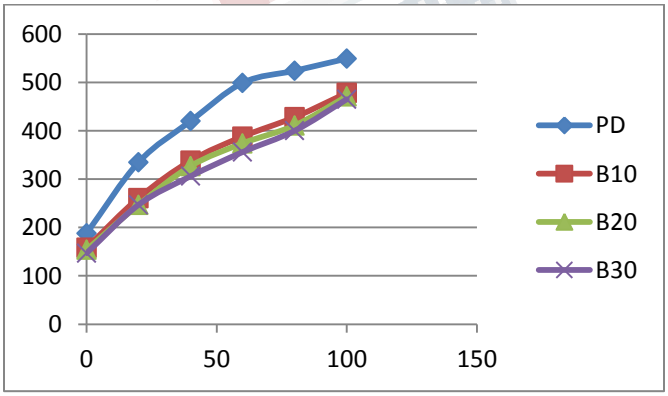

Fig 6. NOx Vs BP

When different blends of Jatropha oil biodiesel is used in engine then the emission of NOx mainly depends on Availability of oxygen and higher temperatures these are the two important factors which facilitate the production of NOx because at higher temperature nitrogen becomes reactive where at lower temperatures, nitrogen exists as a stable diatomic molecule hence it is not the main facilitator for the production of NOx [6]. At 0 load of an engine, the emission of NOx is 147ppm for JOBD30 154ppm for JOBD20, 158ppm for JOBD10, 188ppm for Pure Diesel. Similarly at 100% load of an engine, the emission of NOx is 465ppm for JOBD30, 471ppm for JOBD20, 478ppm for JOBD10, 549ppm for Pure Diesel [8]. Since there is presence of oxygen molecules in biodiesel, an unrivaled effectiveness and efficiency of combustion was obtained due to temperature of higher peak combustion chamber. It can be seen from the figure, as the engine load is increasing NOx concentration in emission is increasing. This had led to produce higher NOx emissions at higher loads.

8.3 HC vs BP

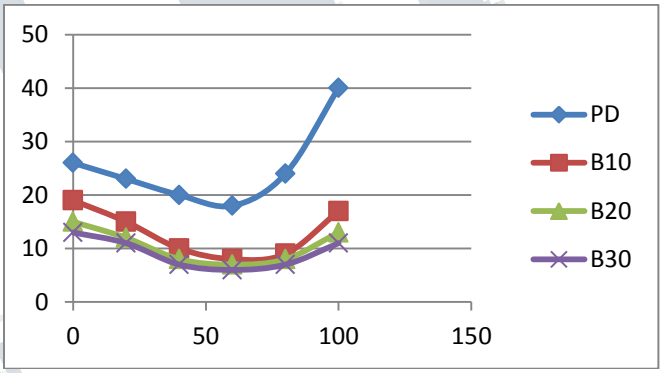

Fig 6. HC Vs BP

When different blends of Jatropha oil biodiesel is used in engine then the emission of HC from CI engine act as Odorants, irritant and some are carcinogenic because of non-homogeneity [2]. At 0 load of an engine, the emission of HC is 13ppm for JOBD30, 15ppm for JOBD20, 19ppm for JOBD10, 26ppm for Pure Diesel. Similarly at 100% load of an engine, the emission of HC is 11ppm for JOBD30, 13ppm for JOBD20, 17ppm for JOBD10, 40ppm for Pure Diesel, As incomplete combustion occurs in the chamber due to non-homogeneity of air fuel mixture, this mixture is lean in some spots and too rich in some other spots of the combustion chamber [11]. This incomplete combustion produces more HC emission or unburned fuel emissions. HC emissions are mainly increased as the load is increasing because of heat liberation (that occurs as the load is increased)We can observe that the emissions of HC are increasing as the percentage of blend decreases and emissions of HC are decreasing as the percentage of blend ratio increases.

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8.4 Opacity vs BP

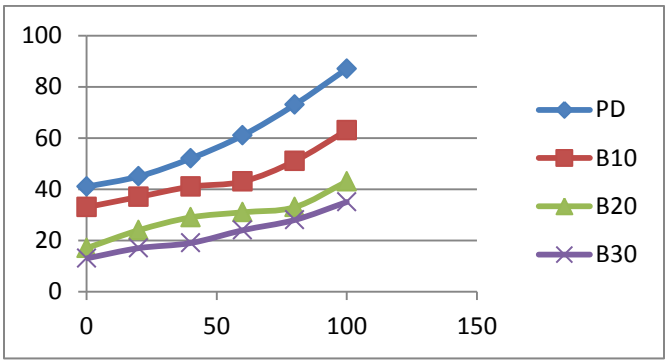

Fig 6. Opacity Vs BP

When different blends of Jatropha oil biodiesel is used in engine then the emission of Smoke opacity is mainly formed due to the complete combustion, as there is availability of excess oxygen that is present in the fuel itself. At 0 load of an engine, the emission of opacity is 13ppm for JOBD30, 17ppm for JOBD20, 33ppm for JOBD10, 41ppm for Pure Diesel. Similarly at 100% load of an engine, the emission of opacity is 35ppm for JOBD30, 43ppm for JOBD20, 63ppm for JOBD10, 87ppm for Pure Diesel [7]. Emission of smoke opacity is increased with increase in engine load. This is due to poor atomization of Jatropha oil (Poor atomization is due to heavier fuel molecules, higher viscosity, and low volatility) [6].

8.5 CO_2 vs BP

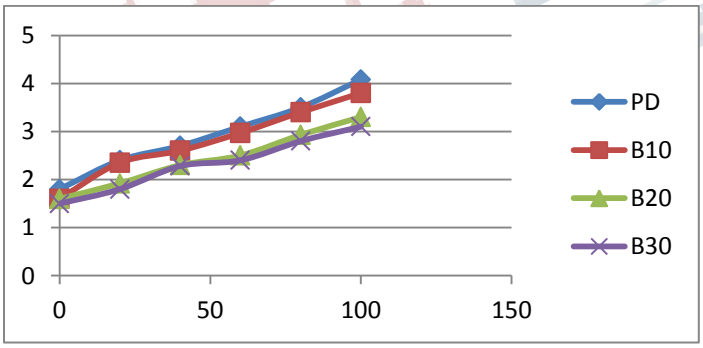

Fig 6. CO2 Vs BP

When different blends of Jatropha oil biodiesel is used in engine then the emission of CO_2 is as follows. At 0 load of an engine, the emission of CO_2 is 1.5ppm for JOBD30, 1.6ppm for JOBD20, 1.6ppm for JOBD10, 1.8ppm for Pure Diesel. Similarly at 100% load of an engine, the emission of CO2 is 3.1ppm for JOBD30, 3.3ppm for JOBD20, 3.8ppm for JOBD10, 4.08ppm for Pure Diesel [9]. We can observe that the emissions of CO2 are increasing with increase in engine load. As the engine load is increasing, the amount of fuel that is entering for combustion in combustion chamber also increases, the measure of fuel that is entering into the combustion chamber for complete combustion also increases by producing an increase in temperature inside the cylinder. At higher temperature the combustion in the cylinder gets better and this burning of fuel results in higher CO_2 emissions

9. CONCLUSION

When different blends of Jatropha biodiesel oil is experimented on the engine at different loads then it was concluded that JOBD30 is less emissive in CO, NOx , HC , Opacity , CO2 when compared to other blends of Jatropha Oil Biodiesel [12]. Hence we can conclude that JOBD30 is less emissive so we can use this in commercial purposes to save our environment. By using biodiesel the sooth particles, which cause damage to humans is greatly reduced.

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