Performance and Emission Parameters with Blending of Jatropha Biodiesel in Diesel Engine

Ravindra Gupta, Omkamal Vashi, Vaibhav Bhatt

Abstract**: *In the current situation limited resources of petroleum products and their higher consumption rate and pollution increase research work for an alternative option for internal combustion engines. The emissions draws from these fuels also pollute the environment more day by day. Jatropha oil from jatropha seed is one sources of biodiesel which is a less polluting, locally available and reliable renewable resource. In this research work, performance and analysis doing on 5 HP single cylinder of vertical arrangement and direct injection CI engines with rope brake dynamometer with a blending of jatropha biodiesel. The performance and emission parameter of the diesel engine were found with different proportions of biodiesel in a existing diesel fuel. The result shows that by using up to 20 % biodiesel in diesel, compatible performance parameters with reduced emissions can be achieved.***

Keywords: Alternative fuel, Biodiesel, Jatropha oil, Specific fuel consumption;

I. INTRODUCTION

Alternative fuels are renewable sources can be used as fuel instead of conventional fuel like petroleum. These fuels are produced from other resources than crude oil. And biodiesel is one of the alternative fuels for automobile and power sector. Biodiesel which is a biofuel is generally produced from vegetable oils (both edible and non-edible), alcohol, and animal fats. It can be derived from various sources like neem oil, palm oil, soybean, ricebran, mustard oil, Jatropha and waste cooking oil. The properties of this biodiesel are similar to diesel fuel and it can be used as blends and alone. The process used to make biodiesel from these sources is called transesterification. In this process by using alcohol, in the presence of a catalyst with the use of sodium hydroxide (NaOH) or potassium hydroxide (KOH) convert the raw renewable oil into methyl or ethyl esters and by-product glycerol. Also, Acid and alkaline esterification were performed to get the final product [1].

Manuscript published on January 30, 2020.
* Correspondence Author
Ravindra Gupta*, Automobile Engineering Department, Parul University, Vadodara, India. Email: ravindra.gupta@paruluniversity.ac.in
Omkamal Vashi, Automobile Engineering Department, Parul University, Vadodara, India. Email: omkamal.vashi@paruluniversity.ac.in
Vaibhav Bhatt, Automobile Engineering department, KITE, Anand, Email:Vaibhav.7888@gmail.com

The reaction process in transesterification is influenced by different factors like types of catalysts, reaction time temperature of reaction, glycerides to alcohol ratio [2].

There are several advantages of biodiesel over conventional fuel as listed below.

- Made from renewable resources
- Easy to produce
- Less pollutant
- Easily mixed with diesel fuel
- Less inflammable
- No need to the conversion of engine
- Has higher cetane no

There are some limitations like low volatility, high viscosity, poor atomization of fuel particles and require more pumping power with the blending of biodiesel. Also, require more investment for the production of biodiesel and requires more quantity of oil to limit the use of biodiesel. But still, we can use biodiesel in many applications like generator set, marine and hybrid public transport and industries application [3].

The oil which extract from Jatropha seed that grow on jatropha plant is converted into biodiesel by transesterification can use in diesel engines up to some proportions and get benefits from duel fuel properties. The properties of jatropha biodiesel are almost similar as diesel fuel but also some properties are very high like ignition point and viscosity [4].

jatropha tree grows all over India alongwith other developing countries under agro-climatic conditions and it is commonly found in tropical regions of the world. The jatropha seed consist of 50-60% oil. A Country like Bangladesh can produce a large amount of biodiesel from jatropha curcas and save the economy. Jatropha biodiesel can be used in heavy-duty vehicles and locomotives. Biodiesel Jatropha used in the Indian railway with blends of B5, B10, and B20 in diesel and found that no adverse impacts on engine performance.

The Potential of Jatropha cultivation in India

In India around 40 million ha. out of 63 million ha. wasteland can be developed by plantation of Jatropha. The Jatropha starts fruiting in 2 years after planting in the field and continues up to 30-40 years. So high oil content, seed yield and resistant against insect quality seed should be used for plantation.

The Novod Board has created model plantation of Jatropha in the different states of India for parental material [5].

Sunilkumar et al. [6] investigated Performance analysis with blends of thumba biodiesel on CI engine by various proportions and found that better performance parameter and BSFC with less pollution. K. Srithar et al. [7] performed analysis on high speed CI engine with two different proportions of pongamia pinnata oil and mustard oil and conclude that fuel consumption is comparable with diesel and low CO and CO2 emission. K.A. Abed et al. [8] found that brake thermal efficiency and HC, CO emission lower with cooking biodiesel and NOx, CO2 emission increased with biodiesel. Dragos Tutunea et al [9] analyzed four-cylinder diesel engine with sunflower oil-based biodiesel and found that with the use of biodiesel CO and HC emission lower compared to diesel fuel and NOx was found higher due to high volatility and viscosity compared diesel fuel. Many researchers [10-12] also worked on different biodiesel like palm biodiesel, Waste cooking oil biodiesel, Castor seed oil on diesel engine and found that performance parameter is lower compared to diesel and less CO, CO2, HC emission produced by blending of Biodiesel.

In this research work, blends of jatropha biodiesel in a proportion of B10, B20, and B30 with diesel were used as biodiesel fuel and done output performance parameter and emission characteristics on four stroke single cylinder vertical CI engine and compared with diesel.

II. METHODOLOGY

2.1 Transesterification of Jatropha oil to Biodiesel

There are different technologies to produce biodiesel [13].

a. Homogeneous Catalysts Method for Transesterification
b. Heterogeneous Catalysts Method for Transesterification
c. Enzymatic TE of Vegetable Oils
d. Non-Catalytic Super Critical Vegetable Oils to FAME

Transesterification

Transesterification is process of chemical reaction between triglycerides present in oil and alcohols like methanol and ethanol with use of catalyst to produce alkyl esters in form of methyl or ethyl ester and by product glycerol.

Triglyceride +Alcohol $\rightleftharpoons$ Alkyl Esters + Glycerols

The use of methanol is more preferred due to its cheap and easy availability. And this reaction carried out in the presence of homogeneous catalysts like potassium hydroxide KOH, sodium hydroxide NaOH, or heterogeneous catalyst like enzymes, titanium silicates, etc and finally conversion of triglyceride-diglyceride - mono-glycerides – glycerol by one mole of ester liberated [14].

In this project work, purchased Jatropha oil is used to reaction with methanol alcohol in the presence of NaOH to produce methyl esters and glycerol. A known amount of sodium hydroxide NaOH based on a percentage of the oil weight. This Sodium hydroxide NaOH is premixed with methanol and added to the Jatropha oil. This mixture heated at a particular temperature up to 30 min and it is controlled by electrical heating, mixed by magnetic stir for a few mins then stays this mixture to settlement about twelve hrs. The separated bio-diesel coming out at the top of mixture and part of glycerine settled at the bottom of flask. Table 1 shows the comparison of various properties of jetropha biodiesel and diesel.

Fig: 1. JATROPHA SEEDS

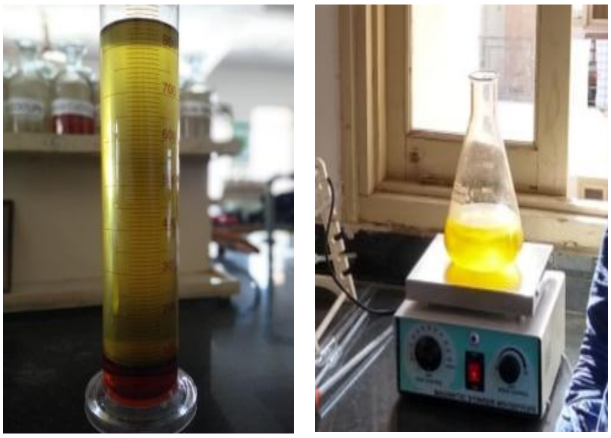

Fig: 2 Production of Biodiesel in laboratory

Table 1: Comparing Petroleum-Based Diesel And Jatropha Biodiesel

Parameter	Jatropha based Methyl Ester	Diesel
Density at ,kg/m3	885	830
Viscosity, mm2/s	4.84	2.6
Flash point, °C	162	70
Pour point, °C	-6	-20
Ash content,%	Nil	0.02
Carbon residue,%	0.025	0.17
Sulphur content,%	NIl	-
Iodine value	104	-
Saponification value	190	-
Calorific value, MJ/kg	37.2	42
Cetane number	51.6	46

2.2 EXPERIMENTAL PERFORMANCE AND ANALYSIS

For this Research work, we perform experiment on single vertical cylinder, four strokes, and water-cooled, direct injection CI engine. Fig 3 is the Schematic diagram of the experimental setup and Table 2 shows details of technical specification of the engine.

Table 2: SPECIFICATIONS OF THE ENGINE

BHP/KW	5/3.72
Compression Ratio	16.5:1
Rated Speed (rpm)	1500
Bore (mm)	80
Stroke (mm)	110
Number of stroke	4
Number of Cylinder	1
Type of ignition	Compression Ignition
Method of loading	Rope Braking
Method of starting	Crank start

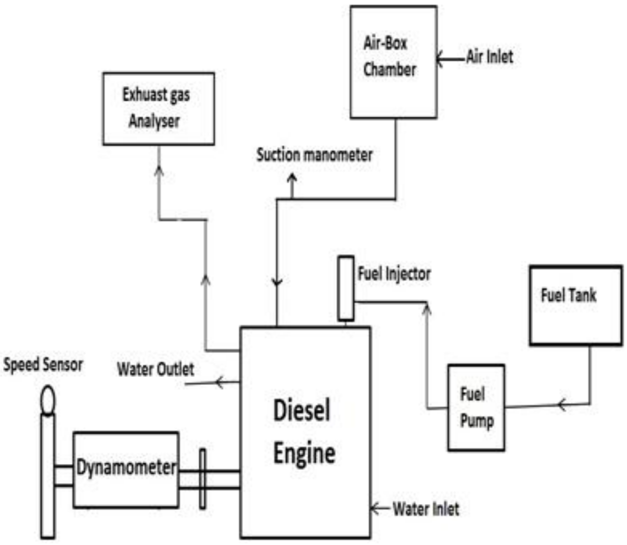

Fig 3: Schematic diagram of Experiment set up

Fig 4: Engine Test Rig

III. EXPERIMENTAL PROCEDURE

- Before starting the engine check the fuel supply line, electrical supply, and availability of cooling water.
- Set the dynamometer to zero loads and run the engine till it attains the working temperature
- Keep the zero load, adjust the fuel supply so that the engine attains its rated speed and run the engine till the steady -state condition is achieved
- Note down the fuel consumption rate, cooling water, air flow rate and exhaust temperature and Emission parameter.
- Now, Set the dynamometer to 25% of full load, adjust the fuel supply so that the engine attains the desirable rate speed after steady state is reached, note down the dynamometer reading, fuel consumption rate, cooling water temperature, air flow rate, exhaust gas temperature ,and Emission Parameter.
- Repeat the experiment at 50, 75, and 100% of full load at constant speed.
- Then do the same procedure by blending of biodiesel with diesel for different ratios.
- These different ratios are:

10% Jatropha fuel + 90% diesel
20% Jatropha fuel + 80% diesel
30% Jatropha fuel + 70% diesel

MEASURING INSTRUMENT:

- Rope brake dynamometer with the electronic weight machine
- Calibrated burette and a stopwatch
- Airbox chamber with water Manometer
- Rotameter
- AVL Gas Analyser

IV. RESULTS & DISCUSSION

A. PERFORMANCE PARAMETERS

Brake Specific Fuel Consumption

The comparison of Brake thermal specific consumption (BSFC) with respect to output power for the various blend of biodiesel in diesel is plotted in Fig 5. The ratio of mass fuel consumption (m_f) to brake power (BP) is called Brake specific fuel consumption. It is observed that BSFC is higher for all blended fuel than pure diesel under various loading condition and it is due to high viscosity, and lower heating value of biodiesel. But also found that 20% blended fuel having comparable value with diesel.

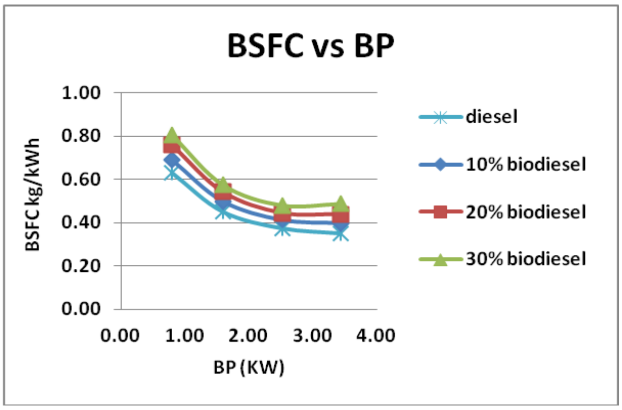

Fig 5: BSFC vs BP

Brake Thermal efficiency

The ratio of Brake power (BP) to Heat supplied (Qs) is called Brake thermal efficiency. The Changes in brake thermal efficiency with respect to output power for different percentages of biodiesel in diesel is plotted in Fig 6. It was that Brake thermal efficiency with Jatropha blended biodiesel is lower than diesel fuel due to poor atomization and Vaporization. Brake thermal efficiency increases as the brake power increases for under various loading conditions.

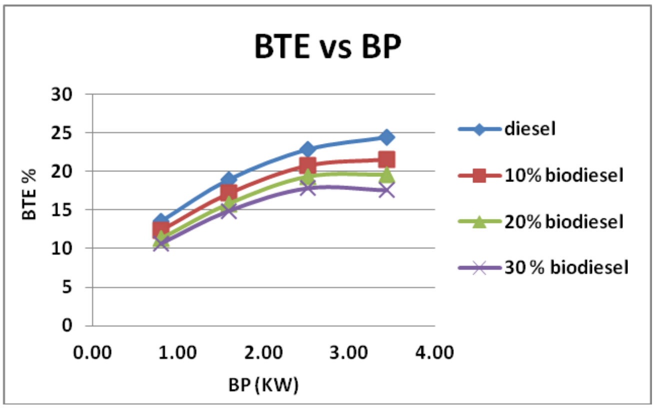

Fig 6: BTE vs BP

Brake Specific Energy Consumption

The variation of Brake specific energy consumption BSEC with respect to output power for various blends and diesel shown in fig 7. BSEC is a variable which independent of fuel consumption and it is energy input to produce the unit power output. It is found that BSEC of all fuels decreases with increasing the load. It was found to be a marginal difference between blended and diesel fuel and this due to lower calorific value and high kinematic viscosity of biodiesel.

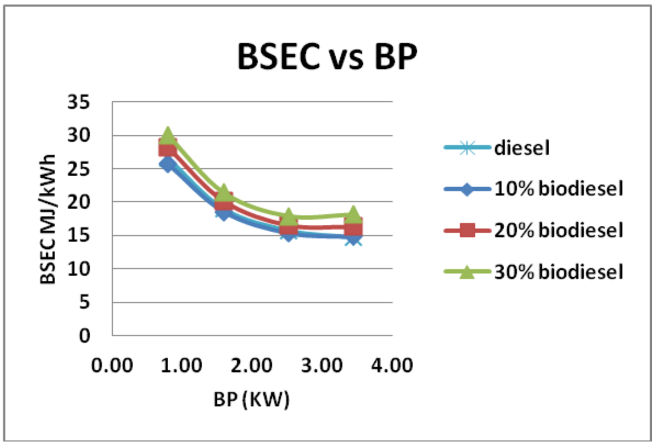

Fig 7: BSEC vs BP

B. EMISSION CHARACTERISTICS

Unburned hydrocarbon emission (UBHC)

Fig. 8 show that unburned hydrocarbon emissions for all blended biodiesel and diesel fuel. It is shown that UBHC emissions decrease with Jatropha biodiesel blending percentage than diesel. It was also seen that UBHC emission increased with increasing load on the engine. The reason was that Jatropha biodiesel has high ignition quality and high oxygen which doing complete reaction.

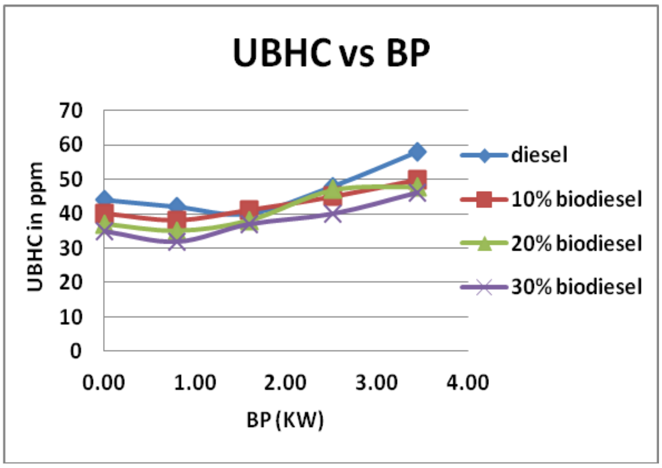

Fig 8: Unburned Hydrocarbon Emission

Carbon monoxide emission (CO)

Fig 9 shows that, Carbon monoxide emission for blended and diesel fuel alone. We observed that for different fuels, the carbon monoxide (CO) emission levels were increased with power output because of increase in volumetric fuel consumption. The physical properties of fuel and chemical reaction with air in the cylinder affect the formation of CO emission. It can be seen that the Carbon monoxide pollution contain with blended of Jatropha biodiesel is less compare to diesel fuel. The reason for decreseing of CO with use of Jatropha biodiesel is to converts carbon monoxide to carbon dioxide with more oxygen present it.

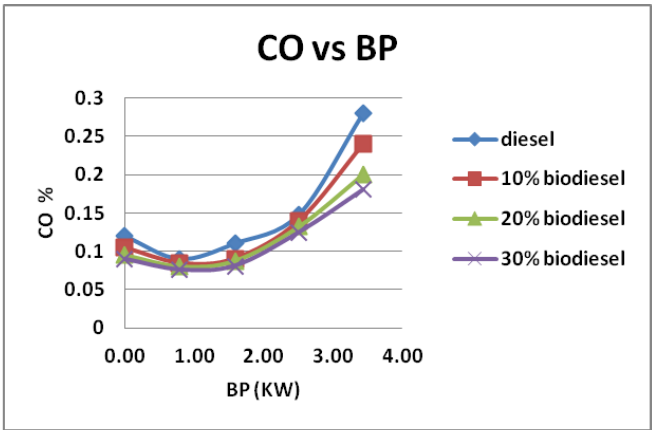

Fig 9: Carbon Monoxide Emission

Carbon Di-oxide Emission (CO_2)

Fig. 10 shows that carbon dioxide (CO_2) pollutant levels for diesel fuel and with blended jatropha biodiesel with power output. The CO_2 emissions were increased due to increase in volumetric efficiency. It also found that the CO_2 pollution with blended Jatropha biodiesel is less compare to diesel. This is due to the more oxygen contain of jatropha biodiesel.

Retrieval Number: E6467018520/2020©BEIESP
DOI:10.35940/ijrte.E6467.018520
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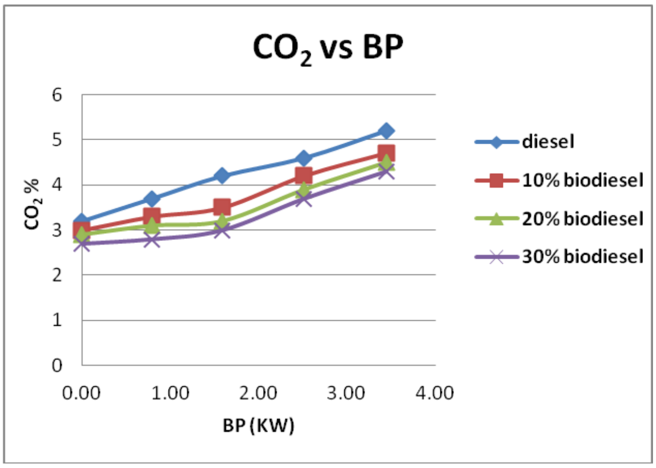

Fig 10: Unburned Hydrocarbon Emission

Oxides of Nitrogen Emission (NOx)

It was shown that NOx emission increase with blended biodiesel and diesel fuel with increasing load. The NOx emissions of diesel and Jatropha biodiesel fuels are plotted in fig 11. The formation of NOx depends on cylinder temperature so with the usage of biodiesel oxygen contain augment high peak cylinder temperature to lead NOx.

It was seen that with blend of Jatropha biodiesel, peak temperature getting after combustion process.

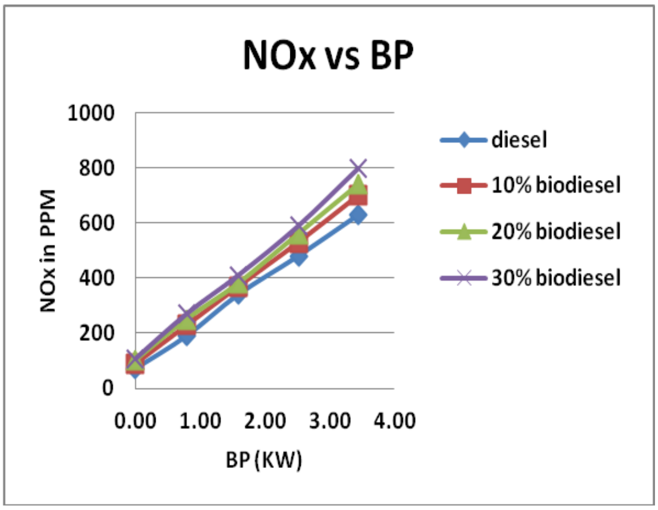

Fig 11: Nitro-Oxide Emission

V. CONCLUSION

In this research work, the engine output parameter and emission parameter of single-cylinder vertical direct injection diesel engine with adding up to 30 percentages of Jatropha biodiesel in diesel analyzed with varying loads on engine and differentiate with neat diesel fuel. From the Analysis, we can suggest that Jatropha biodiesel is an alternative fuel for the economic running of compression ignition engines and reduced environmental pollution to some extent.

The following observation made from experimental work and summarized as follows:

1. The engine performance characteristics with blended biodiesel are compatible with diesel fuel.
2. There is a noticeable reduction in emissions characteristics except NOx for blended Biodiesel compared to diesel fuel.
3. NOx emission with Jatropha biodiesel blend is higher than diesel due to high peak temperature.

Finally, we conclude that biodiesel from Jatropha oil could help to reduce energy security or resources to some extent without losing engine performance. And also help to control air pollution by using some percentage of biodiesel with diesel fuel.

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NOMENCLATURE

BP	= Brake Power
BSFC	= Brake Specific Fuel Consumption
BSEC	= Brake Specific Energy Consumption
BTE	=Brake Thermal Efficiency
HC	= Hydrocarbon
UBHC	= Unburned Hydrocarbon
CO	= Carbon Monoxide
CO2	= Carbon Dioxide
NOx	= Oxides of Nitrogen

NaOH = Sodium Hydroxide
KOH = Potassium Hydroxide
ppm = Parts per million
KW = Kilowatt

AUTHOR'S PROFILE

Mr. Ravindra Gupta, presently working as Assistant professor of Automobile department at PIT, Parul University since 8 years. Area of Research is Alternative fuel, Thermal Engineering, Nanofluid.

Mr. Omkamal vashi presently working as Assistant professor of Automobile department at PIT, Parul University since 6 years. Area of Research is Alternative fuel, hybrid vehicle.

Mr. Vaibhav Bhatt, presently working as Assistant professor of Automobile department at KITE, since 5 years. Area of Research is IC Engine, Automobile System.