ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 2, Issue 11,November 2017

Emission characteristic of a dual cylinder diesel engine fuelled with jatropha biodiesel and producer gas

[1] Vadlamani Praveen Kumar, [2] Mrityunjay, [3] SiddharthAgarwal, [4] Gitimayakar, [5] Sonit Singh

[1][2][4][5] School of Mechanical Engineering, KIIT University, Bhubaneswar, Odisha-751024

[3] School of Electronics Engineering, KIIT University, Bhubaneswar, Odisha-751024

A Abstract: **The present paper gives an experimental study of the operation of a dual cylinder diesel engine working in dual fuel mode using jatropha oil biodiesel (JOBD) as the pilot fuel and producer gas as the primary fuel. JOBD is produced by esterification and transesterification process catalysed either by acids or bases followed by water wash and heating. Biodiesel require high temperature for ignition, so that is the only reason they are used in dual fuel mode. Utilization of biodiesel in vehicles reduces the excessive use of petroleum fuels and also reduces the emission of soothe particles. They also show positivity towards maintaining the balanced and sustainable growth of our economy. The experimental study shows the variation of emission characteristics of carbon dioxide (CO2). Carbon monoxide (CO), Hydrocarbon (HC), nitrogen oxides (NOx) and smoke opacity with respect to change in load. Along with the emission characteristics fuel consumption is also observed in order to appeal out the savings of the fuel. It has been found that while operating under different biodiesel blends and with varying load (Brake power) the emission levels of HC, CO,NO and smoke opacity have had a considerable reduction while CO2 emissions has increased.**

Index Terms— Biodiesel, Renewable energy, Transesterification, Jatropha

I. 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 [1]. 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. 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 [1],[2]. Biodiesel first came into existence during 1990's but due to its ignition and cold starting problems it is still under experimental study only. So this problem can be solved using dual fuel mode where producer gas along with JOBD is used to run the engine. The incomplete combustion of fuels results in emissions so biodieselalong with producer gas burns completely resulting in lesser emissions.

Fig.1 Jatropha seeds

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. In this experimental investigation Jatropha Curcas is used for the production of JOBD using transesterification process. Jatropha seeds are rich in oil and contribute around 37% for the production of oil [3]. Jatropha can be grown in less fertile soils but requires a lot of water. It helps in preventing soil erosion and increases the fertility of the soil throughout the life cycle. The jatropha plant finds its place in the production of biodiesel and it is also used for medical purposes [4]. Along with advantages the major disadvantage of Jatropha is it is highly toxic.

Fig. 2 Jatropha Curcas oil

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 2, Issue 11,November 2017

Table.1 Physical properties of JOBD [3]:

Properties	Values
Specific gravity	0.87to 0.89
Kinematic viscosity@ 40^0C	3.7 to 5.8
Cetane number	46 to 70
Cloud point ^0C	-11 to 16
Pour point ^0C	-15 to 13

II. PRODUCTION OF JATROPHA BIODIESEL

The production of JOBD involves 5 stages which are mentioned in figure 2. As the seeds of jatropha are acidic in nature the crude oil extracted from the seeds is also acidic. So in order to reduce the acidic property and to neutralize the oil transesterification is done followed by the remaining stages of production [5]. Transesterification is a process in which the crude oil along with methanol or ethanol is heated up to 550C using the catalyst KOH for 2 hours. During the transesterification process glycerol is formed as by-product along with the JOBD oil [6].

Jatropha oil + Methanol $\xrightarrow{KOH}$ JOBD+ Glycerol (1)

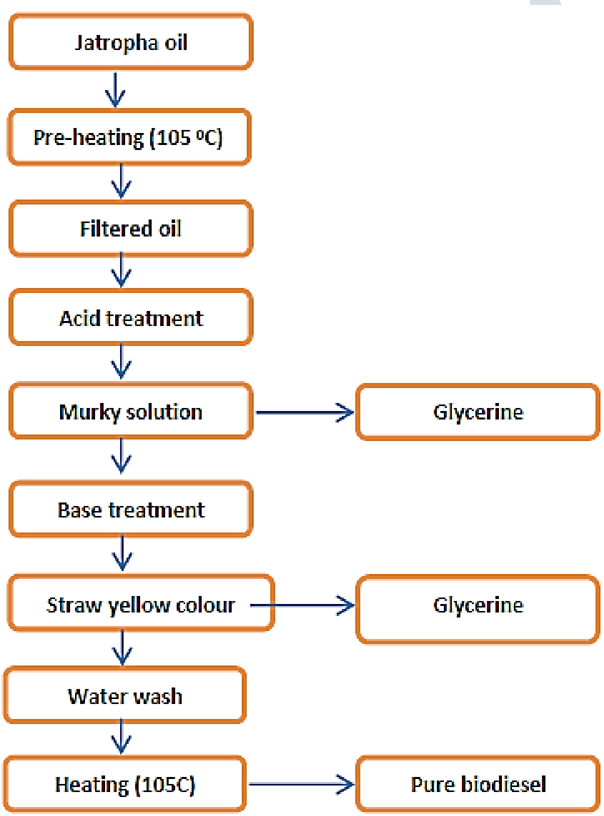

Fig.3 Layout process chart of JOBD[1]

Table2. Process Parameter for biodiesel production from Jatropha oil [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	$52\text{-}55^0C$
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

III. SOURCE OF PRODUCER GAS

Producer Gas is a combination of different gases which are Hydrogen (H), Carbon monoxide (CO), Nitrogen(N), and Carbon dioxide (CO2). Gasification is the method used to produce producer gas from the following materials like coal and biomass. Biomass and coal are rich in carbon content. Producer gas finds its place in automobiles, cooking stoves, blast furnaces etc. Biomass is converted into producer gas through a process called gasification and the process involves different thermal processes [7].

- Drying
- Pyrolysis
- Combustion
- Reduction

All the above thermal processes are used to convert Biomass into gas under partial combustion.

IV. BIODIESEL BLENDS PREPARATION

After the base catalysed transesterification process the oil is water washed and it is heated to remove the water particles. Then the oil is tested for its physical and chemical characteristics and it is compared with either European or ASTM standards. If the oil meets the required standards then it is tested for emission characteristics. The Jatropha bio oil is now blended with diesel in different ratios as JOBD10, JOBD20, JOBD30 and it is sent into the engine along with producer gas [8]. The emission values of these blends are compared with standard diesel with producer gas.

V. ENGINE SETUP

The present sets of experiments were conducted on a four stroke single cylinder direct injection water cooled diesel engine equipped with eddy current dynamometer. Table.3

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 11,November 2017

shows the test engine specifications. Two separate fuel tanks with fuel flow control valves were used for the operation of the engine on biodiesel and producer gas. One of the fuel tanks was filled with individual blends of JOBD10, JOBD20, JOBD30 and the other tank was filled with producer gas. The engine was operated at full load and constant speed and the emission characteristics like CO2, HC, CO, NOx emissions were measured for diesel and all test with along with producer gas. Figure 3 shows the test engine setup.

Table. 3 Test engine specifications [1]

Sl. No.	Particulars	Description
1	Engine Type	4-stroke, single cylinder, Bi-fuel engine
2	Stroke length	110mm
3	Bore diameter	80mm
4	Compression Ratio	16:1
5	Rated speed	1500rpm
6	Rated power	3.5 KW

Fig. 4 Test engine[1]

VI. RESULTS AND DISCUSSION

A. Load vs Carbonmonoxide(CO)

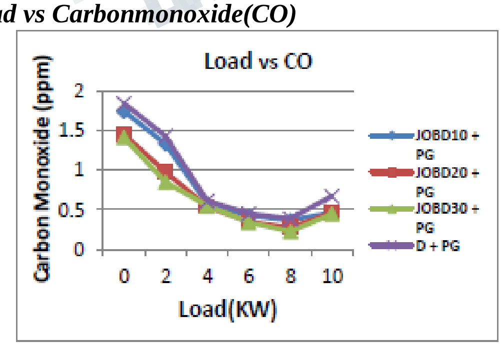

Fig.5 Load Vs CO

With increase inLoadthe exhaust levels of carbon monoxide decreases gradually up to some point and then increases. The emission levels of JOBD10+ PG is very less when compared with other blends but as the load increases the emission value of JOBD30+PG is less in comparison with JOBD10+PG. With reference to the above graph, it is clear that JOBD30+PG CO emissions are less when compared with other blends [9].

B. Load Vs Nitrogen oxide (NOx)

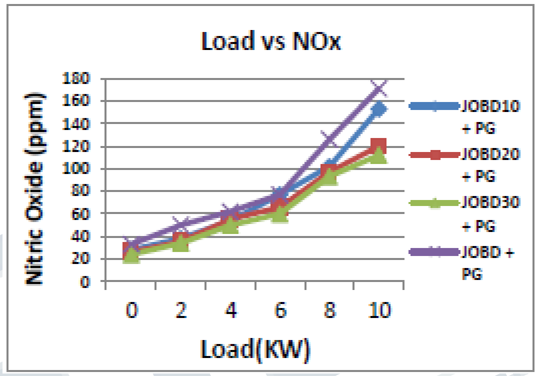

Fig.6 Load Vs NOx

Nitrogen combines with oxygen to form nitrous dioxide which results in respiratory disorders. Considering the above graph drawn between BP and NO it is clear that the levels of NO emissions increase as BP increases. JOBD30 and JOBD20 show reduced levels when compared with JOBD10, diesel and producer gas. From the above graph it can be clearly seen that JOBD30+PG shows reduced emissions of NOx when compared with other blends [10].

C. Load Vs Hydrocarbon (HC)

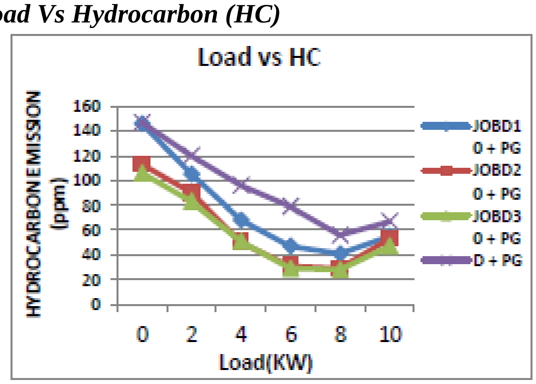

Fig.7 Load Vs HC

Considering the above graph, it is clear that as load increases the HC emissions reduce gradually and it is high when the engine runs with pure diesel and PG followed by JOBD10+PG, JOBD20+PG and JOBD30+PG. Soot particles are formed more when the engine is running with D+PG due to partial combustion and this leads to skin diseases when comes into contact with human body. JOBD30+PG stands at first place in reduced HC emissions and this blend helps in the reduction of soot particles [11].

D. Load VsSmoke Opacity

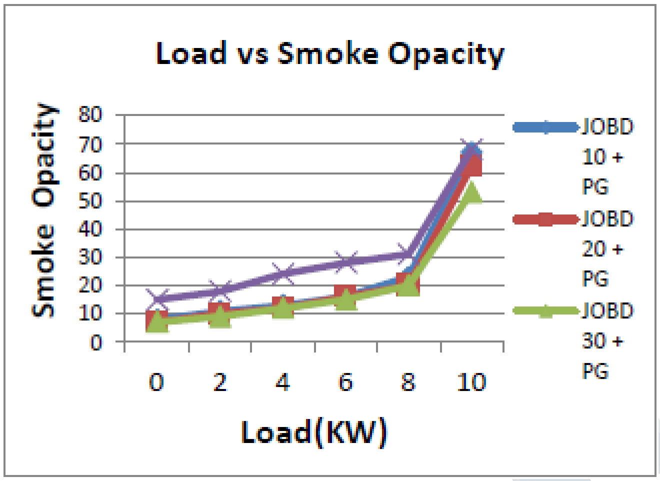

Fig.7 Load Vs Smoke Opacity

Opacity is defined as the degree to which the smoke blocks the light. Poor maintenance is one of the reasons for smoke opacity. It is clear from the above graph that the opacity increases as BP increases and it is low for JOBD30+PG followed by JOBD20+PG, JOBD10+PG, D+PG. Smoke opacity increases at a faster rate after 8KW load so it is desired to maintain the load below 8KW for reduced Opacity [12].

E. Load Vs Carbon dioxide (CO2)

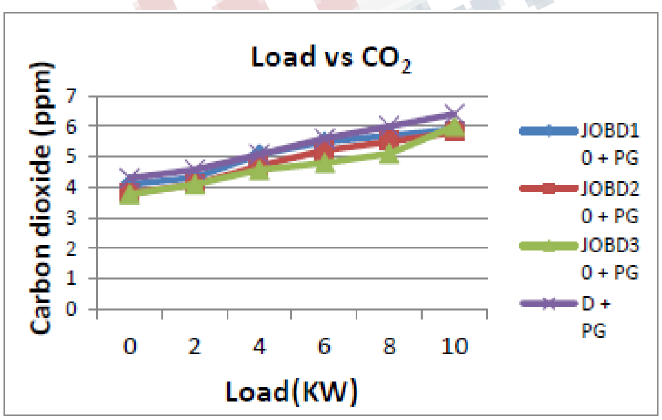

Fig.8 Load Vs CO2

Carbon dioxide along with methane is the major causes for global warming and they form a part of greenhouse gases. From the above graph one can conclude as BP increases CO2 emissions increase gradually and it is almost equal to that of diesel. But it is quite less for JOBD30+PG during 6 and 8 KW loads. So taking into consideration the data at those loads one can come to a conclusion that CO2 shows reduced emissions when the engine runs with JOBD30+PG [13].

VII. CONCLUSION

The present study proves that the diesel engine have the capability to run successfully without any modification of the engine. The important findings are listed below

- The emissions of CO are high under reduced load.
- The emissions levels of NOx shows an increasing trend as load increases but it is very high during 8 and 10KW load.
- The HC emissions show a reducing as well as increasing trend but it is high at reduced loads.
- The smoke opacity follows near equality but after the 8KW load it suddenly increases.

The CO2 emissions are nearly equal and increases gradually. So by comparing the graphs between biodiesel and producer gas with diesel, we can conclude that biodiesel blend with biodiesel 30% and diesel 70% along with producer gas is optimum to run the compressed ignition engine with moderate efficiency. By using this blend diesel can be saved by 30% and more.

REFERENCES

[1] G. Hemanth, B. Prashanth,Nayan Benerjee,Tuhin Choudhuri,Mrityunjay, “Dual fuel mode operation and its emission characteristics in diesel engine with Producer gas as primary fuel and Jatropha biodiesel as pilot fuel”,International journal of mechanical engineering and technology, Volume 8, Issue 4, pp:138-147, April 2017.

[2] Nayak,S.K.,Behera,G.R.,Mishra,P.C.,Kumar,A., ”Functional characteristics of jatropha biodiesel as a promising feedstock for engine application”,Volume 39,Issue 3, pp: 299-305,2017.

[3]Nayak,S.K.,Mishra,P.C.,Kumar,A.,Behera,G.R.,Nayak,B,. ”Experimental investigation on property analysis of karanja oil methyl ester for vehicular usage”, Volume 39,Issue 3,pp 306-312, 2017.

[4] Prashanth, B.,Saiteja,R.,Sunil Kumar,B.,Swarup Kumar Nayak., 'Performance Characteristics of a four Stroke Single Cylinder Diesel Engine Fuelled with Waste Cooking oil and Diesel Blends", Proceedings of International Conference on Emerging Trends in Mechanical Engineering(ICETIME-2016).pp:747-751, 2016.

[5] Nayak,S.K.,Mishra,P.C.,"Investigation on jojoba biodiesel and producer gas in dual-fuel mode", Volume 38,Issue 15, pp:2265-2271, 2016.

[6] Nayak,S.K.,Mishra,P.C., 'Emission from utilization of producer gas and mixes of jatropha biodiesel", Volume 38,Issue 14,pp:1993-2000, 2016. [7] P. Sirisomboon , P. Kitchaiya, T. Pholpho., W. Mahuttanyavanitch, "Physical and mechanical properties of Jatropha curcas L. fruits, nuts and kernels", Volume 97, Issue 2, , pp:201–207, June 2007.

[8] Nayak, C., Pattanaik,B.P.,Nayak, S.K.,"Effect of preheated Jatropha oil and Jatropha Oil methyl ester with producer gas on diesel engine performance", Volume 9,Issue 1, ,pp: 1709-1722,2014.

[9] K. Openshaw. "A review of Jatropha curcas: an oil plant of unfulfilled promise",Biomass and Bioenergy, volume19 Issue 1, pp. 1–15,2000.

[10] K. Pramanik.,"Properties and use of Jatropha curcas oil and diesel fuel blends in compression ignition engine",Renewable Energy Journal, Volume 28,Issue 2,pp. 239–248,2003.

[11] J. Martínez-Herrera, P. Siddhuraju, G. Francis, G. Dávila-Ortíz, K. Becker.,"Chemical composition, toxic/antimetabolic constituents, and effects of different treatments on their levels, in four provenances of Jatropha Curcas", L. from Mexico,Food Chemistry, Volume 96, Issue 1, pp. 80–89, 2006.

[12] G.D.P.S. Augustus, M. Jayabalan, G.J. Seiler, "Evaluation and bio induction of energy components of Jatropha CurcasBiomass and Bioenergy", Volume 23, Issue 3, pp. 161–164, 2002.

[13] Swarup Kumar Nayak, Bhabani Prasanna Pattanaik "Experimental Investigation on Performance and Emission Characteristics of a Diesel Engine Fuelled with Mahua Biodiesel Using Additive", Energy Procedia. Vol. 54, pp-569-579.