ISSN (Online) 2456-1290

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

Emission characteristics of a dual fueled diesel engine powered with Jatropha oil and Producer gas

[1] B.Prashanth, [2] Swarup Kumar Nayak. [3]C. Manisha
[1], [2] School of Mechanical Engineering, KIIT University, Bhubaneswar, 751024
[3] Mallareddy college of engineering and technology, Secunderabad, Telangana, 500014

Abstract: **-- The present paper gives an experimental study of twin cylinder diesel engine operated in dual fuel using jatropha oil methyl ester as the pilot fuel and producer gas as primary fuel. Producer gas is produced by the gasification of Babul wood and the jatropha oil is produced by the transesterification process. Global warming and change in the balance of ecosystem is due to the emission of different harmful gases in to the atmosphere. This has led scientists to find an alternative to the present problem and one among them is alternative fuel (Biodiesel). A remarkable growth is observed in the automobile as well as industry sectors and this resulted in the continuous exploitation of fossil fuels. The utilization of biodiesel in the engine reduces the excessive use of petroleum fuels and also reduces the excessive emission of soot particles. Biodiesel is degradable and the production process is simple which makes it easy for everyone to understand. The experimental study shows the variation of emission characteristics of HC, CO, CO2and pilot fuel savings with respect to varying load when the engine is operated in dual fuel mode.**

Index terms- Engine, jatropha oil, producer gas, gasification, transesterification, emission.

I. INTRODUCTION

Demand of energy is increasing and accordingly the supply of the fuels is decreasing which is responsible in economic crisis. The demand for energy is a challenging task for scientists and researchers in finding an alternative way in replacing the present existing fuels. The global demand for the exploration of the renewable energy sources has been increased. This resulted in the development of alternative fuels (renewable energy) which can fulfill the present demand [1].Some common renewable energy sources are biofuels, geothermal, biomass, hydrogen, solar energy, wind energy etc... Most of the developed countries have their renewable energy power plants and the developing countries along with the developed countries are carrying out with their research works for the development of renewable fuels. As the demand for non-renewable energy is increasing day by day, a day comes when the demand and supply ratio of non-renewable energy sources will be completely unbalanced leading in energy crisis. Researches are trying their level best in the production of alternative fuels from renewable energy sources. Biodiesel is the best alternative fuel for diesel engines [2]. After the independence India competed with several other countries in terms of development and this competency has led to the continuous exploitation of fossil fuels leading to energy crisis. Biodiesel plays an important role in determining the competency of the nations. Biodiesel has the capability to replace the present fossil fuels. Biodiesel is produced from edible as well as non-edible oils but edible oils form a major part of diet so they are not used for the production of biodiesel [3]. Literature survey reveals that diesel can be saved upto70-90% when the engine is operated in dual fuel using renewable fuels. The particulate emission i.e the soot particles which are emitted from the diesel engines due to incomplete combustion of fossil fuels causes skin diseases and if inhaled can cause lung cancer. So the main objective of using dual fuel is to reduce soot particles and NOx emissions

II. SOURCE OF JATROPHA

Jatropha plant belongs to the family of “Euphorbiaceae” and genus of “Jatropha L”. Jatropha curcas is one of the best oil seed plants for the production of biodiesel. Jatropha is a deciduous large shrub which can grow upto 5mts height which smooth gray bark. It is grown in central America and well adapted to the tropics and subtropics of the world. When compared to other oil seed crops Jatropha is hard plant and t has shirt gestation period. Jatropha can adapt to different climatic conditions and can be grown in most of the areas. The oil produced from Jatropha is of high quality and the oil recovery is very high Jatropha can be cultivated in barrel lands and less productive lands. The oil seed produced by Jatropha plants acts as a source of energy in the form of biodiesel [4]. The major advantage of the Jatropha is it can be grown in poor

ISSN (Online) 2456-1290

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

soils, leaving the rich soils in the cultivation of other consumable goods. The oil produced from Jatropha is highly toxic.

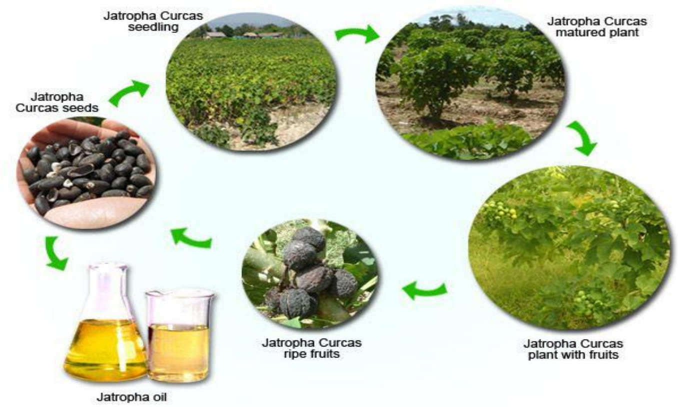

Fig. 1 Jatropha cycle for oil production

A. Advantages of Jatropha

- Jatropha is mainly used in production of biodiesel.
- Jatropha plants are hard and can be cultivated in drought areas.
- Jatropha can adapt to different climatic conditions it can be grown in wastelands and poor soils.
- Due to Jatropha plantation, wasteland soil fertility can be increased.
- Plantation of Jatropha prevents soil erosion.

B. Dis-advantages of Jatropha Seeds

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

III. PRODUCTION OF BIODIESEL FROM JATROPHA SEEDS.

Transesterification is the primary stage in the production of biodiesel from waste vegetable oils or algae. Different methods adopted for carrying out the transesterification reaction are common batch process, micro-wave methods, ultrasonic methods and even supercritical processes. Chemically biodiesel contains mono-alkyl esters of long chain fatty acids. Most commonly used alcohol for the production of biodiesel is methanol due to its low cost and physiochemical advantages. Methanol is added to the oil to produce methyl esters. Ethanol can also be used to produce an ethyl ester but the cost of production increases as the cost of ethanol is more. Production of biodiesel starts with transesterification process [1].

A. Transesterification reaction:

Transesterification is a process of converting jatropha oil into jatropha biodiesel using the catalyst KOH or NaOH in the presence of Methanol or Ethanol. Titration is done in order to find how much alkaline is required to neutralize the free fatty acids thereby ensuring the complete transesterification process. Base (NaOH, KOH) catalyzed transesterification is faster than acid (H2SO4, HCl) catalyzed reaction because the reaction is reversible and excess alcohol is required to shift the equilibrium to the product side. Alkali (base) catalyzed reaction is most often used for the production of biodiesel as it is most economical. For the completion of transesterification process stoichiometrically 1:3 molar ratio of triglycerides to alcohol is required. Transesterification is a process of converting glyceride and alcohol to form ester and glycerol in the presence of catalyst NaOH or KOH.

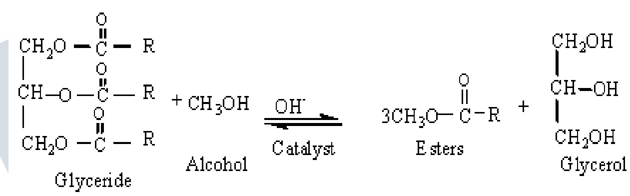

Fig. 2 Transesterification chemical reaction

C. Methodology of preparation of biodiesel

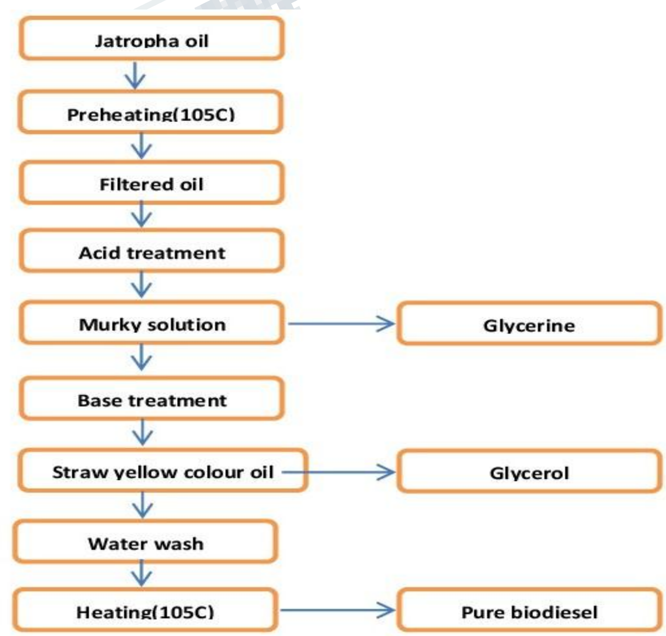

Fig. 3 Layout flow chart of biodiesel production

IFERP
connecting engineers... developing research

ISSN (Online) 2456-1290

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

Table. 1 Process Parameter for biodiesel production from Jatropha oil Methyl Ester [5]

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

IV. SOURCE OF BIOMASS GENERATED PRODUCER GAS

Producer gas is generated by a process known as gasification and the typical composition of producer gas comprises of Hydrogen (H), Carbon dioxide (CO2), Nitrogen (N), Carbon monoxide (CO). Producer gas is generally produced from waste wood, corn, coal and biomass. In this experiment babul wood is used to produce the gas and the equipment used is downdraft gasifier. Woody biomass is a traditional fuel where heat generation is required because of its high calorific value and less ash content [6]. Small pieces of Babul wood with approximate size of 25mm length and 25mm diameter is prepared in the laboratory and used as a feedstock for the down draft gasifier. The Babul wood pieces are preheated in order to decrease the moisture content and to increase the calorific value of the gas. Conversion of Biomass into producer gas involves 4 thermal stages [1].

- Drying
- Pyrolysis
- Combustion
- Reduction

V. EXPERIMENTAL SETUP AND EXPERIMENTATION

The experimental setup consists of a twin cylinder 4-stroke diesel engine coupled with electrical resistance type loading devices and generator. The schematic diagram of the experimental setup is shown in the figure3. The producer gas is sent through the filters for the removal of moisture, tar and dust particles. A mechanical valve is provided at the outlet of the filter pipe in order to control the gas flow rate. Orifice meter and manometer are connected to the surge tank for the measurement of gas flow rate [7]. The flow of gas and air can be separately measured by using manometers. The emission tests are carried out separately in fossil fuel and in dual fuel mode under variable gas flow rates such as 0 kg/hr, 10.73 kg/hr, 14.32 kg/hr, 17.71 kg/hr and 20.69 kg/hr under different load conditions of 0, 2, 4, 6, 8, 10 KW. Thermocouples are used to measure the temperature of the gas before entering the cooling system and found to be 458^{0}C. The temperature of the gas leaving the cooling chamber was found to be 37^{0}C. Operating the engine at different loads the performance and emission characteristics were observed.

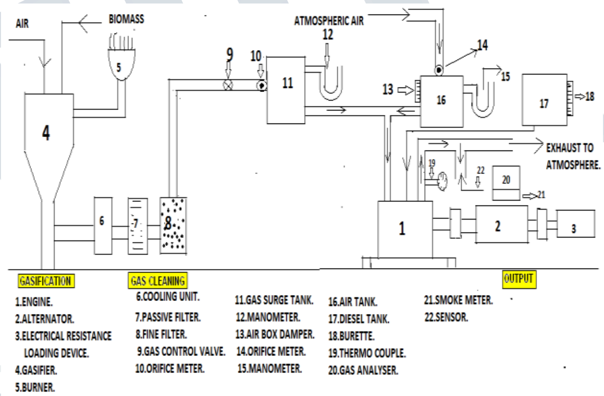

Fig.4 Schematic Diagram of dual fuel engine test rig.

VI. RESULT AND DISCUSSION

A. Carbon monoxide vs. Bake Power

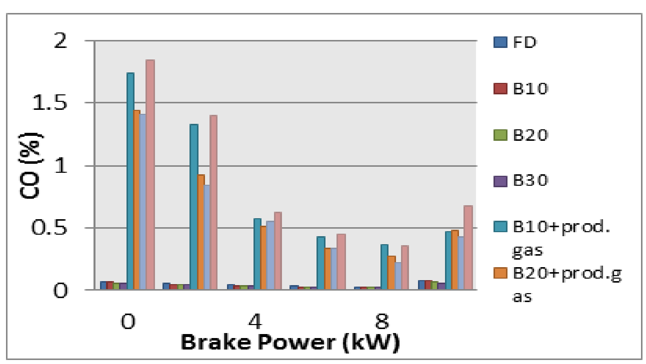

Fig. 5 Carbon monoxide vs. Brake Power

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

Increase in brake power results in the decrease of CO emissions for different diesel blends. The CO emissions are more in the case of FD+prod.gas and decrease gradually with increase in Brake power and it is lowest for B30.The CO emissions are more at the early stages of the Brake power and decreases gradually [8]. The emission of CO is more in the case of dual powered engines and less in the case of single fuel.

B. Hydrocarbon Vs Brake Power

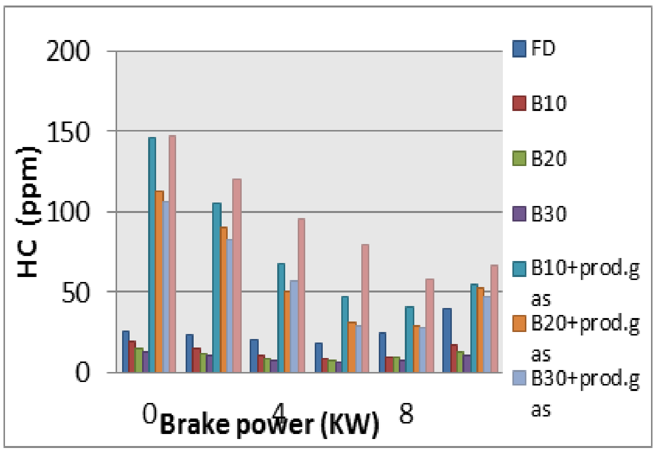

Fig.6 Hydrocarbon vs. Brake power

With reference to the above graph it is clear that Hydrocarbon emission decreases with increase in load for both modes of operation. Hydrocarbon emissions are high at no load and zero load as compared to other loads [9]. For both modes of operation HC and CO emissions follow a similar trend.

C. Smoke Opacity Vs Brake Power

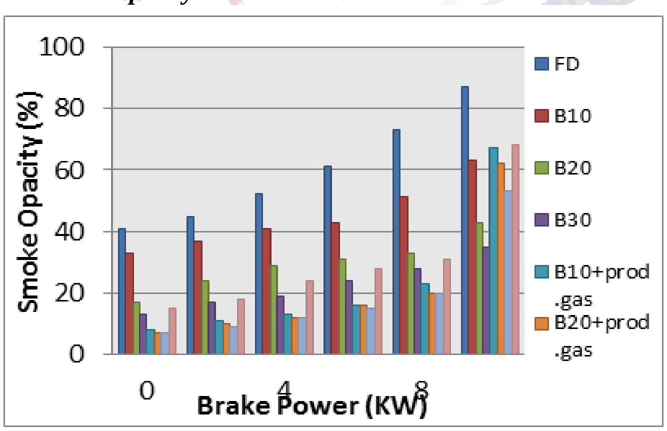

Fig.7 Smoke Opacity vs. Brake power

Opacity is defined as the degree of measurement to which smoke blocks light. Opacity measures the amount of smoke coming from a diesel-powered vehicle. Poorly maintained engines are sometimes the cause of excessive smoke which results in the blocking of light [10]. The above graph shows the variation of Smoke opacity with brake power. Smoke opacity is more in the case of FD followed by B10, B20, FD+prod.gas, B30, B10+prod.gas, B20+prod.gas and the lowest is B30+prod.gas. So B30+prod.gas produce the least smoke so it can be considered as a best alternative in replacing the diesel.

D. Carbon dioxide vs. Brake Power

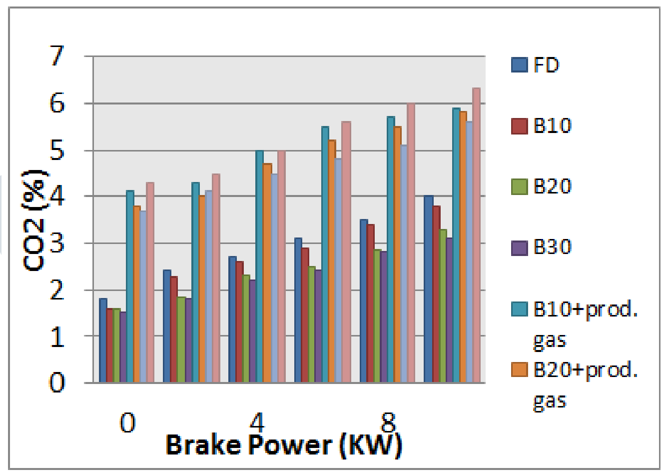

Fig.8 Carbon dioxide vs. Brake power

The above graph depicts the emission of CO_2 with respect to Brake power. With increase in load the CO_2 emissions gradually increase .The presence of oxygen molecule in biodiesel along with higher carbon-hydrogen ratio causes higher CO_2 emission. It is evident that with the use of Biodiesel a higher temperature as well as higher pressure can be achieved when compared to diesel. The ignition temperature required for the combustion of biodiesel is higher than that of diesel which results in the complete oxidation of carbon monoxide to carbon dioxide. The complete oxidation is one of the causes for the formation of more CO_2 in the tailpipe exhaust. Similarly when biodiesel and producer gas are used more amount of energy is produced resulting in the release of more amount of CO_2 at the tailpipe exhaust. As the above graph shows the emission of CO_2, it is more in the case of biodiesel+producer gas and low for biodiesel. The net CO_2 emissions of biodiesel are more when compared with diesel, as the biofuel crops absorb CO_2 and release oxygen during their photosynthesis process [11]. As zero load using biodiesel+producer gas the CO_2 emissions are highest in the

ISSN (Online) 2456-1290

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

case of Fossil diesel (FD)+producer gas and lowest in the case of B30+producer gas. Similarly using biodiesel the CO2 emissions are high in the case of Fossil diesel (FD) and lowest in the case of B30 [12].

E. Pilot Fuel Saving vs Brake Power

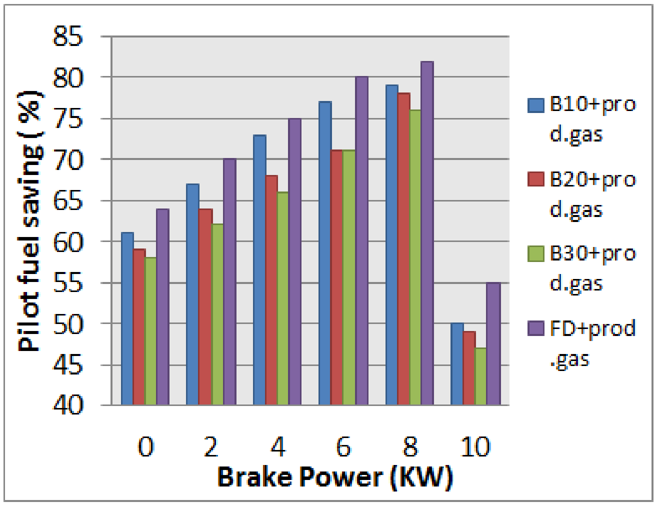

Fig. 9 Pilot fuel savings vs. Brake power

Figure 8 gives an overview of the total fuel savings when the engine is operated in dual fuel mode under varying load at different gas flow rates. As producer gas flow rate increases diesel savings increases and at full load the diesel fuel savings are minimum [13]. It is clear from the above figure that the diesel fuel savings have gone up to 83% at kW for maximum gas flow rate and for minimum gas flow rate the diesel fuel savings gone up to 38.4% .

VII. CONCLUSIONS

The present study proves that diesel powered engines has the capability to run successfully in dual fuel mode without any engine modifications. The important findings are listed below.

- The performance of the engine was decreased when it is operated in dual fuel mode at all test conditions.
- Similarly the emissions like Co2 and smoke opacity are increased.
- The emissions like CO, HC are greatly reduced in all the test conditions.
- At 8 kW load maximum fuel savings was observed to be 83% at maximum gas flow rate.

After careful analysis of the above study it was found that the engine operated in dual fuel shows low performance and high emissions due to improper combustion of the producer gas. Hence the quality of the producer gas should be increased by using some technique or modification of the engine can be looked upon as future work.

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., Mishra, P.C. 2016$_f$. Application of Nagchampa biodiesel and rice husk gas as fuel. Energy Sources, Part A: Recovery, Utilization and Environmental Effects. 38 (14), pp. 2024-2030

[3] Banapurmath, N.R., *et al.*, 2009. Combustion characteristics of a 4-strokeci engine operated on Honge oil, Neem oil and Rice Bran oils when directly injected and dual fuelled with producer gas induction. *Renewable energy*, 34, 1877-1884.

[4] Prasanth,B.,Saiteja,R.,Sunil Kumar,B.,Swarup Kumar Nayak.2016.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).747-751

[5] Bhattacharya, S.C., *et al.*, 2001. A study on a multi-stage hybride gasifire engine system. *Biomass and Bioenergy*, 21, 445-60.

[6] Dasappa, H. and Sridhar, H.V., 2011. Performance of diesel engine in dual fuel mode using producer gas for electricity power generation. *International journal of Sustainable Energy*, iFirst, 1-16.

[7] Nayak, S.K., Mishra, P.C. 2016$_a$. Investigation on Jojoba Biodiesel and producer gas in dual fuel mode. Energy Sources, Part A: Recovery, Utilization and Environmental Effects. 38 (15), pp. 2265-2271

[8] Henham, A. and Makkar, M.K., 1998. Combustion of simulated biogas in a dual-fuel diesel engine. *Energy Conversion Management*, 39, 2001-2009.

ISSN (Online) 2456-1290

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

[9] Nayak, S.K., Mishra, P.C. 2016$_b$. Emission from sawdust biomass and diesel blends fuel. Energy Sources, Part A: Recovery, Utilization and Environmental Effects. 38 (14), pp. 2050-2057.

[10] Kaupp, A. and Goss, J.R., 1984. Small scale gas producer engine systems.

[11] Martinez, J.D. *et al*., 2012. Syngas production in downdraft biomass gasifiers and its application using internal combustion engines. *Renewable Energy*, 38, 1-16.

[12] Nwafor, O.M.I., 2000b. Effect of advanced injection timing on the performance of natural gas in diesel engine. *Sadhana*, 25 (1), 11-20.

[13] Nayak, S.K., Mishra, P.C. 2016$_c$. Emission characteristics of diesel fuel composed of linseed oil (Linum Usitatissium) blends utilizing rice husk producer gas. Energy Sources, Part A: Recovery, Utilization and Environmental Effects. 38 (14), pp. 2001-2008.