Performance Evaluation of Stationary IC Engine using Biofuels & its Blends

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Abstract--- This Research deals with the Performance Evaluation of stationary IC engine Using Biofuels (Diesel, Biodiesel, and Biogas) and its Blends. The various Blends of Diesel, Palm Biodiesel and Biogas are used and conducted the test on Stationary IC Engine. The experiment results were analyzed for the selection of better Blend of Diesel, Biodiesel and Biogas for IC Engine for better performance with reduced pollution.

Keywords: IC Engine, Performance, Diesel, Palm Biodiesel, Biogas & Emission.

I. INTRODUCTION

India has become third largest economy in the world, Due to higher population there is very huge demand of energy supply. India has very limited crude reserve & its 70% fuel requirement is met with import. Although there have always been some I.C. engine fuelled with non-gasoline or diesel oil fuels, there numbers have been relatively small. Because of the high cost of petroleum products, some third-world countries have for many years been using manufactured alcohol as their main vehicle fuel. Another reason motivating the development of alternative fuels for I.C. Engine is concern over the emission problems of gasoline engines.

Biogas Production technology from various types of raw materials is well established and biogas plants of various sizes, and designs suited to different raw materials are already operating in large numbers throughout the country.

India has very large cattle population. Cattle dung can be used to produce Biogas.After removing hydrogen sulphide & moisture Biogas becomes fuel fit to be used in IC Engine.

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat) with an alcohol. Biodiesel production is a modern and technological area for researchers due to constant increase in the prices of petroleum diesel and environmental advantages.

India has very large costal area where Palm trees can be grown from which we can obtain Palm oil which can be converted to Palm Methyl Ester. This Biodiesel (Methyl Ester of oil) is also a promising fuel for IC Engines.

In this project Diesel Engine was run Single fuel mode with test fuels like Diesel, Biodiesel and Biogas as well dual fuel mode with test like Diesel + Biogas, Biodiesel + Biogas.

Engine performance & Exhaust emissions for different test fuel are compared and it was concluded that with Blends in gives quiet satisfactory result in terms of Engine performance & Exhaust Emissions as compared to Diesel When Engine was run on Dual fuel mode with Biogas as one of the fuel.

It was possible to run the Engine with no any major modifications Engine run quite satisfactory HC & CO Emissions was slight higher when Biogas was used as fuel.

A. Biogas

Biogas is produced by anaerobic decomposition of organic wastes by suitable bacteria.it contains (55-65) percent methane,(30-40) percent carbon dioxide and the remainder are impurities like H_2S,H_2,N_2 gases.

The main source of production of biogas are crop residue, wet cow dung, vegetable wastes, water hyacinth,alage,poultry or piggery droppings, human waste,bagasse,rice-husk etc. Any organic material of animal or plant which is easily bio-degradable can be the source of biogas production.

Biogas can be produced by digestion pyrolysis or hydrogasification. Digestion is a biological process that occurs in absence of O_2 and presence of anaerobic organism at atmospheric pressures and temperatures of 35˚C-70˚C .The container in which the digestion takes place is called digester.

Bacteria used for production of biogas can be divided into two major groups based on their oxygen requirements to grow. The bacteria which grows in presence of oxygen is called aerobic bacteria and the other which grows in the absence of oxygen is called anaerobic bacteria. When organic matter undergoes fermentation, the anaerobe bacteria extracts oxygen by decomposing the biomass at low temperatures up to 65˚C in the presence of moisture.

Property name	Biogas
Calorific value	21500 kJ/m^3
Octane rating	120
Cetane number	0.7
Stoichiometric A:F ratio	9.5:1 (by volume)
Ignition temperature	650℃
Specific Gravity	0.84
Density	1.0994 Kg/m^3
Flame speed	25 cm/s
Flammability limits	7.5 (vol.% in air)

Table. 1: Properties of Biogas

Biogas is a mixture of gases that is composed chiefly of:

- Methane (CH_4) : 40-70 vol. %
- Carbon dioxide (CO_2): 30-60 vol. %
- Other gases: 1-5 vol. %

- Hydrogen (H_2): 0-1 vol. %
- Hydrogen sulfide (H_2S): 0-3 vol. %

B. Biodiesel

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat) with an alcohol. Biodiesel production is a modern and technological area for researchers due to constant increase in the prices of petroleum diesel and environmental advantages. Biodiesel is a clean-burning diesel fuel additive produced from soybean and other vegetable oils instead of petroleum. Biodiesel is produced from vegetable oils by converting the triglyceride oils to methyl (or ethyl) esters with a process known as trans-esterification.

Biodiesel is used in compression ignition (diesel) engines to enhance engine combustion performance, improve engine lubrication, and reduce air and water pollution caused by the exhaust. Biodiesel blends operate in diesel engines, from light to heavy-duty, just like petroleum diesel fuel. No engine conversions are required at all, unless an engine has old fuel lines. It is a renewable domestically produced liquid fuel that can help reduce the countries dependence on foreign oil imports. Biodiesel refers to a non-petroleum based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, made by Transesterification of vegetable oil or animal fat (tallow), which can be used (alone, or blended with conventional petro-diesel) in unmodified diesel-engine.

Palm oil is the second most traded vegetable oil crop in the world, after over 90% of the world's palm oil exports are produced in Malaysia and Indonesia. Palm oil is still mostly used in the manufacture of food products and is found in one in ten products sold in UK supermarkets. However, palm oil is now starting to be used as an ingredient in bio-diesel and as a fuel to be burnt in power stations to produce electricity. This is a new market for palm oil which has the potential to dramatically increase global demand for this commodity.

Property name	**biodiesel**
Specific Density	0.866
Calorific value	8080Kcal/kg
Cetane no.	48-65
Stoichiometric A:F ratio	13.8
Flashpoint	≥100℃ , Around 160℃
Viscosity (centipoises)	2.8–5.0
Boiling point	330–360℃
Distillation	≤360℃

Table. 2: Properties of Palm Biodiesel

II. Experimental Setup

After preparation of blends of Biodiesel and Biogas, it is tested in engine to check the performance of engine. The experimental setup of engine is given in fig.1.

A. Equipments Used for the Experiment as shown:

- Stationary IC Engine
- Burette
- Mano meter
- Water tank
- Air tank
- Fuel Tank
- Scrubber
- Moister tank
- Biogas Flow meter
- Alternator
- Water Motor
- Pressure gauge
- Valve
- Pipes

Fig. 1: Experimental Setup Diagram

B. Also Instrument for Use measuring various inputs/outputs in Experimental Work.

- Tachometer
- Clamp meter
- Infrared Thermometer with Laser Gun
- Exhaust Gas Analyzer
- Stop watch
- Beakers
- Load Bank
- Balloon

C. Experimental Procedure

- Fill up sufficient fuel in diesel tank.
- Check oil level in the Engine and it should be set up top edge of the flat portion provide over the oil dipstick. If oil level is reduced, add up clean 20w/40 oil to the crank case by opening the valve cover after filling the oil.
- Fill up water in manometer up to half of the manometer height.
- If diesel tank is empty before filling the fuel, remove air bubbles in fuel pipe by opening the vent screw provided at the sides of the fuel pump.
- Lift up decompression lever present at the sides of the valve covers, put the handle over the starting shaft and rotate the shaft. As Engine picks up sufficient speed drop the decompression levers.
- Connect the pipe of biogas plant to scrubber system and extend it to passes through the moisture tank.
- Moisture tank pipe is connected to the biogas flow meter and then connects to engine and control the valves.
- As Engine picks up the speed, switch" ON" the main switch.

- Speed of engine is to be set at constant speed using tachometer for all load conditions.
- Now slowly apply load so that engine gets loaded.
- Open the valve at bottom of the burette. Take sufficient fuel in the burette, close the valves of tank line so that diesel in the burette passes to the engine. Note down the time required to consume 50 ml of fuel.
- Note down,
    1. Engine Speed using tachometer
    2. Volt and amp. at load bank using clamp on multimeter.
    3. Height Difference between two limbs of Manometer connected to air box.
    4. Cooling Water Temperature entering/ leaving jacket using thermometer.
    5. Mass flow rate of cooling water using beaker.
    6. Temperatures of Engine Exhaust Gas using IR Temp. Gun and measuring
    7. HC & CO using exhaust gas analyzer.
- Initial and final reading at Biogas Flow meter for particular time duration to measure biogas consumption.
- Repeat the procedure for different loads.
- After completion of test, remove all load by load bank .Switch OFF the main switch and put off the engine by pressing governor lever near to flywheel.

III. Result And Discussions

A. *Fuel Consumption:*

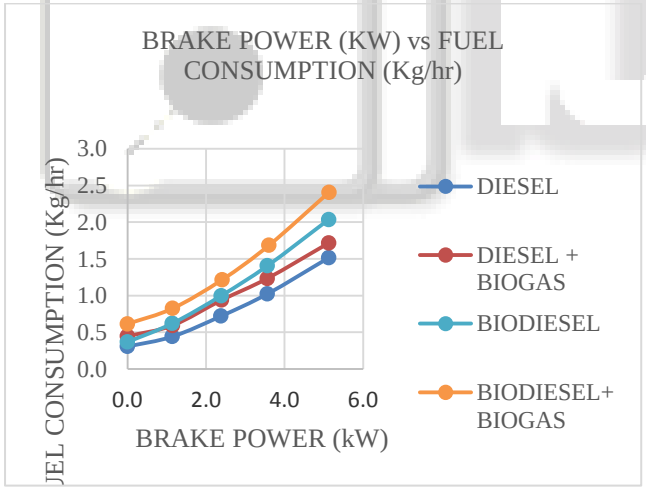

Fig 2: Brake power (kW) vs Fuel Consumption (kg/hr)

From the Fig. of BP Vs FC as shown as Fig. 2, it can be seen that as brake power increases Fuel Consumption also increases for all test fuels.

In general we can say

$FC_{Biogas+biogas} > FC_{Biodiesel} > FC_{Biogas+Diesel} > FC_{Diesel}$

This may be due to 1) Lower heating value of biogas compared to that of diesel and biodiesel 2) Lower heating value of biodiesel compared to that of diesel.

For maximum brake power, fuel consumption in case of diesel is minimum compared to others. Likewise fuel consumption in case of Biodiesel + Biogas is maximum compared to other fuels.

B. *Brake thermal Efficiency (BTE)*

From the Fig. of BP Vs BTE as shown as Fig. 3 , it can be seen that as brake power increases brake thermal efficiency (BTE) also increases for all test fuels excluding full load condition.

It is found that for almost all values of BP, Brake thermal Efficiency (BTE) of diesel during test run is maximum compared to all other test fuels.

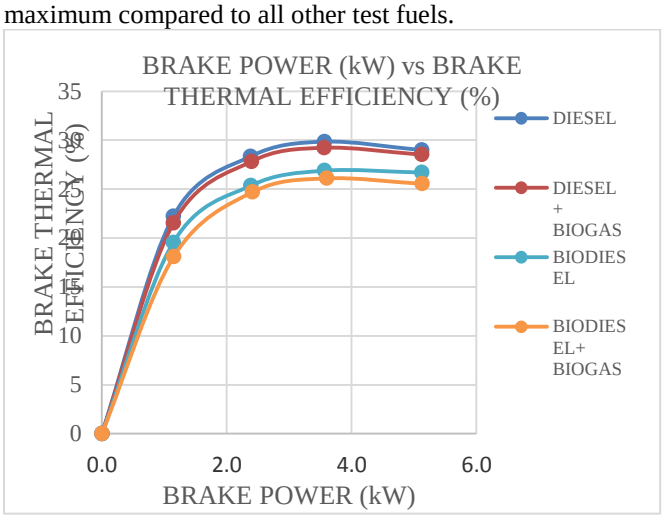

Fig. 3: Brake Thermal Efficiency (%) Vs Brake Power (kW)

In general we can say

$BTE_{Biodiesel+biogas} < BTE_{Biodiesel} < BTE_{Biogas+Diesel} < BTE_{Diesel}$

This may be due to higher fuel consumption in case of 1) biodiesel compared to diesel, 2) dual fuel mode with biogas compared to diesel/ biodiesel.

For maximum brake power, Brake thermal Efficiency (BTE) in case of diesel is maximum compared to others. Likewise Brake thermal Efficiency (BTE) in case of Biodiesel + Biogas is minimum compared to other fuels.

C. *Brake Specific Fuel Consumption (BSFC)*

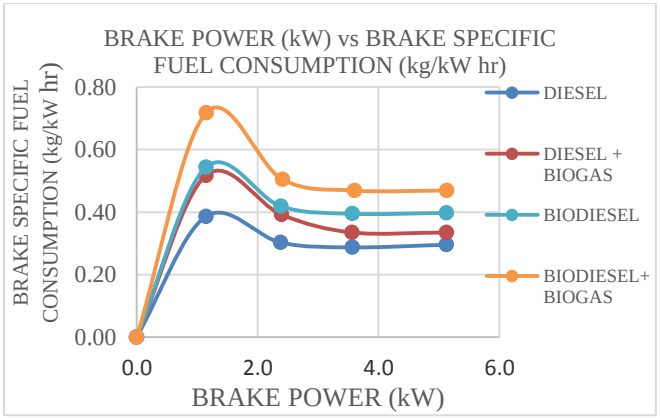

Fig. 4: Brake power (kW) Vs Brake Specific Fuel Consumption (BSFC)

From the Fig. of BP Vs BSFC as shown as Fig. 4 , it can be seen that as brake power increases instantly brake specific Fuel Consumption (BSFC) decreases than after it remain constant for almost all tests fuel.

In general we can say

$BSFC_{Biodiesel+biogas} > BSFC_{Biodiesel} > BSFC_{Biogas+Diesel} > BSFC_{Diesel}$

This may be due to 1) Lower heating value of biogas compared to that of diesel and biodiesel 2) Lower heating value of biodiesel compared to that of diesel.

For maximum brake power, brake specific fuel consumption (BSFC) in case of diesel is minimum compared to others. Likewise brake specific fuel consumption (BSFC) in case of Biodiesel + Biogas is maximum compared to other fuels.

D. Emission result

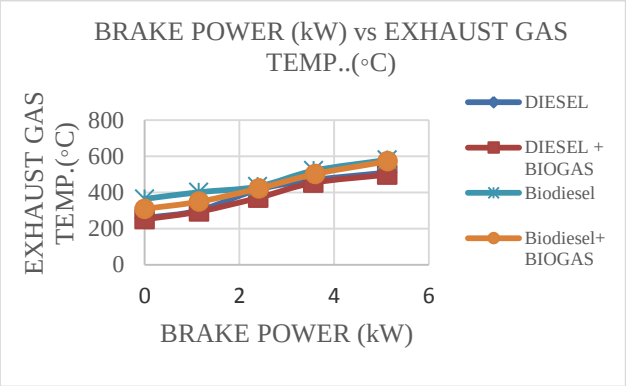

Fig. 5: Brake power (kW) Vs Exhaust Gas Temp. (◦C)

From Fig. 5 of Brake power vs Exhaust Gas Temperature it can be inferred that with increase in Brake power, Exhaust Gas Temp. also increases for almost all test fuels.

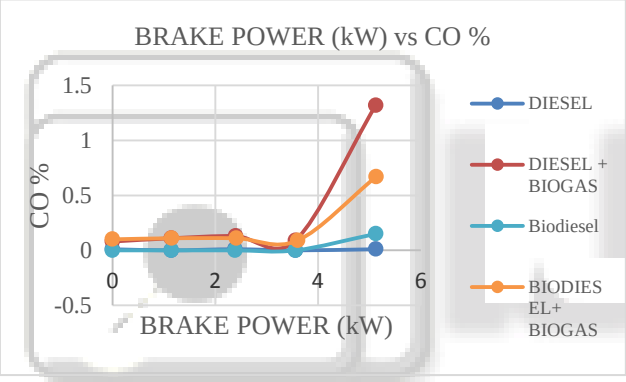

Fig. 6 :Brake power (kW) vs CO %

From Fig. 6 of Brake power vs CO it can be inferred that with increase in Brake power, CO also increases for almost all test fuels.

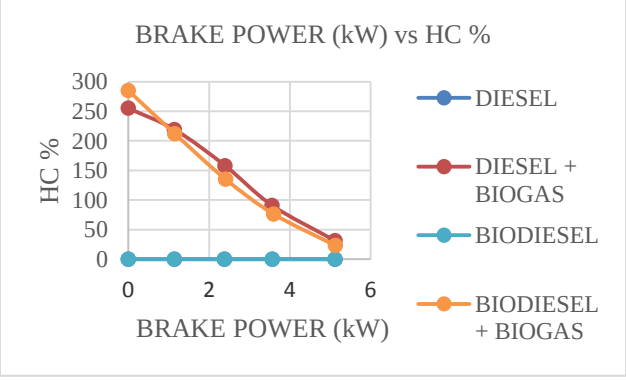

Fig. 7 : Brake power (kW) vs HC %

From Fig. 7 of Brake power vs HC, it can be inferred that with increase in Brake power, HC also decreases for all test fuels.

For Diesel & Biodiesel test fuels constant value of brake power.

IV. Conclusion

- Diesel Engine Can Be Run On Biodiesel Bland & Biodiesel Without Any Modification.
- Diesel engine can be run on Biogas + Diesel & Biogas + Biodiesel fuel mode on providing diesel + biogas mixer .no any other modification is required.
- Due To Lower Heating Value Of Biodiesel, Fuel Consumption Is More And Brace Diesel Efficient Is Less Compared To That Of Diesel.
- Due To Lower Heating Value Of Biogas, Fuel Consumption Is More And Brake Thermal Efficiency Is Less Compared To That Of Diesel.
- Exhaust Emissions Like HC & CO Observed Use Higher In Case Of Biogas Compared That Of Diesel And Biodiesel.

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