Performance and Emission Characteristics of Producer Gas derived from Coconut Shell (Biomass) and Honne Biodiesel with different Configuration of carburetor for dual fuel four stoke direct injection diesel engine

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Abstract: In the present scenario of oil and gas market the fuel bill is the greatest contributor in the nation energy operation. The abundance of biomass in some areas of the world is driving a dramatic cost advantage of gaseous fuel over a diesel fuel, making very economical for engine operation. In this present work producer gas is derived from coconut shell using down draft gasifier and Honne biodiesel is used as fuel for operation of engine. In this work efforts are done to find the best performance and low emission duel fuel engine with 30^0, 60^0, and parallel configuration of carburetor. It was found that parallel flow carburetor improves the dual fuel engine performance with reduced HC, CO_2, CO, smoke and NOx emission level.

Key Words: Biomass, Producer Gas, Dual Fuel Engine, Gasifier, Carburetor, Honne Biodiesel.

Introduction:

India is facing severe problem of energy crisis due depletion of fossil fuels which made price hike in the global market, so the time has arrived to find alternate fuels to meet and match with present and future energy demands of our nation. Biomass and bio diesel are the better alternative fuels which are renewable, cost effective and environment friendly. As India is a agriculture based country lot of sources are available for biomass to obtain gaseous fuel either biogas or producer gas. Biodiesel can be obtained form transesterification process.

Dual Fuel Concept:

National Swedish Testing Institute of Agricultural Machinery, Sweden has reported extensive work on the design and development of closed top charcoal and wood gasifiers for use with the reciprocating engines. In the recent times, have reported work using charcoal gas and biomass based producer gas on a SI engine with a de-rating of 50% and 40% respectively at a CR of 7. However, the same authors state 20% de-rating when worked with producer gas at a CR of 11. They indicate an upper limit of CR of 14 and 11 for charcoal and biomass based producer gas respectively. However, there is no presentation of experimental evidence in favor of these results.

Tatom have reported working on a gasoline truck engine with a simulated pyrolysis gas at a de-rating of 60-65%. The authors have also identified the optimum ignition timings as a function of speed. Park have worked on both naturally aspirated and super charged gas engines. The authors state a de-rating of 34%, compared to gasoline operation and a lesser de-rating in a supercharged mode. The authors discuss aspects relating to fuel-air mixture ratio, flame speed and its relation to the ignition timing for producer gas operation. They have also identified the best possible mixture for maximum power and efficiency along with ignition timing at various speeds.

Properties of Fuel:

Properties of fuels influence the efficient working levels of dual fuel engines. Characterization of fuels forms the first step for efficient knowing its feasibility as fuel for running the engine. As mentioned earlier Honne biodiesel and producer gas derived from coconut shell biomass feed stock were used. Table 1 shows the properties of honne biodiesel, diesel and producer gas. Table 2 shows properties of coconut shell

Properties of Honne Biodiesel, Diesel and Producer Gas			
Property	Diesel	Honne Biodiesel	Producer Gas
Viscosity at 40^0 C (cst)	2.5	4.25	------
Density kg/m³	840	895	1.27
Calorific Value (kJ/kg)	43000	36200	5000
Flash Point (^{0}C)	75	169	-------
Colour	Light brown	Yellowish brown	-------

Table: 1

Properties of Coconut Shell (Biomass)					
S.No	Parameters	Value	S.No	Parameters	Value
1	Moisture content % w/w	9.2	5	Sulphur % w/w	0
2	Ash content % w/w	2.1	6	Nitrogen as N % w/w	.04
3	Volatile Matter % w/w	67.2	7	Calorific Value kJ/kg	20490
4	Fixed Carbon % w/w	19	8	Density kg/m³	404

Table: 2

Configuration of Carburetors:

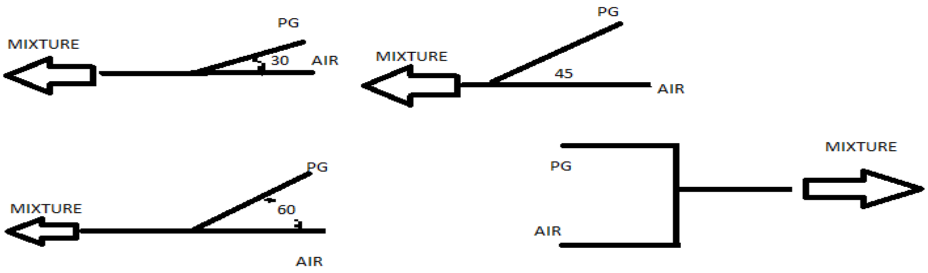

Figure 1: different configurations

Experimental Setup:

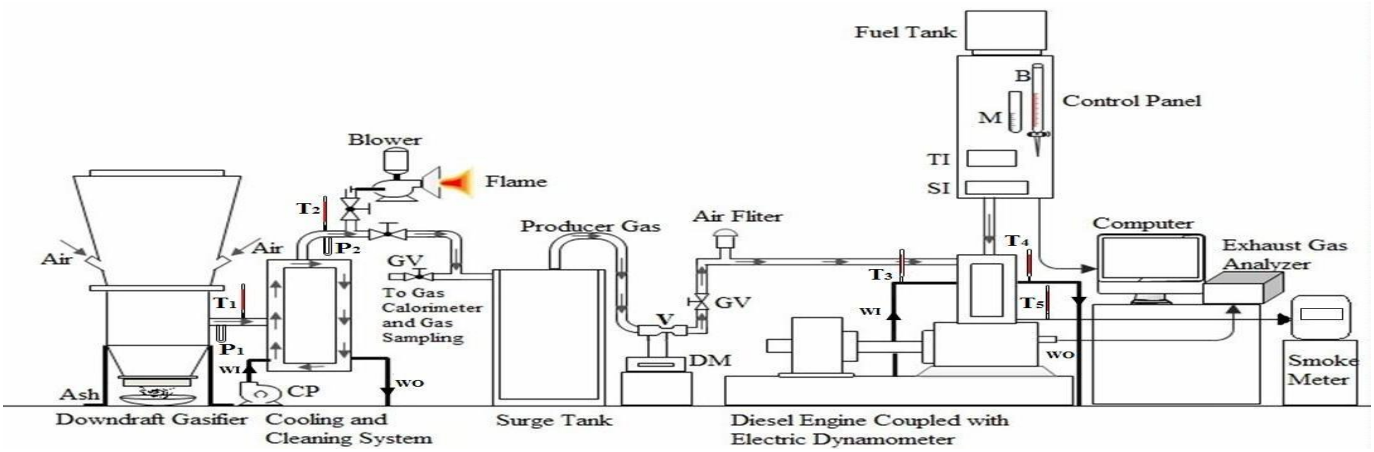

Figure 2: Schematic Diagram of Experimental Setup

Table 3: Specification of Experimental Test Rig			Table 4: Specification of the Downdraft Gasifier	
Sl.	**Parameters**	**Specification**	**Type**	**Down draft gasifier**
1	Machine Supplier	Apex Innovations Pvt Ltd, Sangli. MaharastraState.	Rated capacity	15000kcal/hr
2	Engine Type	direct injection TV1 compression ignition engine with a displacement volume of 662 cc, compression ratio of 17:1, developing 5.2 kW@1500 rpm TV1	Rated gas flow	15Nm^3/hr
3	Software used	Engine Soft	Average gas cv	1000kcal/m^3
4	Nozzle opening pressure	200 - 225 bar	Rated woody biomass consumption	5-6kg/hr
5	Governor type	Mechanical centrifugal type	Hopper storage capacity	40kg
6	Cylinder diameter	0.0875 mtr	Biomass size	10mm (Minimum) 50mm (Maximum)
7	Stroke length	0.11 mtr	Moisture content (DB)	5 to 20%
8	Combustion camber	Open Chamber (DI) with hemispherical cavity	Typical conversion efficiency	70-75%
9	Eddy current dynamometer:	Model :AG - 10, 7.5 KW at 1500 to3000 RPM and Water flows through dynamometer during the use	------------	--------------

Experimental investigations were conducted on a four-stroke single cylinder direct injection water cooled compression ignition engine coupled with down draft gasifier as shown in Figure 1. The specification of the engine and gasifier is given in Table 3 and 4. The engine was always operated at a rated speed of 1500 rev/min. The engine was having a conventional mechanical fuel injection system. The fuel consumption was measured with burette and stopwatch. The injector opening pressure and the static injection timing as specified by the engine manufacturer were 205 bar and 23° before top dead centre (BTDC), respectively. In the present work, the injection timing was kept constant (27° bTDC) and the injection pressure was varied from 220 – 240 bar. However, for Diesel-Producer gas operation injection pressure was kept at 205 bar. for the present research work. The engine had been provided with a hemispherical combustion chamber with overhead valves operated through push rods. A piezoelectric pressure transducer was mounted flush with the cylinder head surface to measure the cylinder pressure. The cylinder pressure was measured with piezo electric transducer fitted in the cylinder head. Five gas analyzer and Hart ridge smoke meter was used to measure HC, CO, NO_x and smoke opacity. All the measurements were done when the engine attained a steady state. For each load, five readings were generated to ensure the accuracy of the data recorded and careful experimental arrangements were made to obtain consistent and repeatable measurements.

Result and discussion:

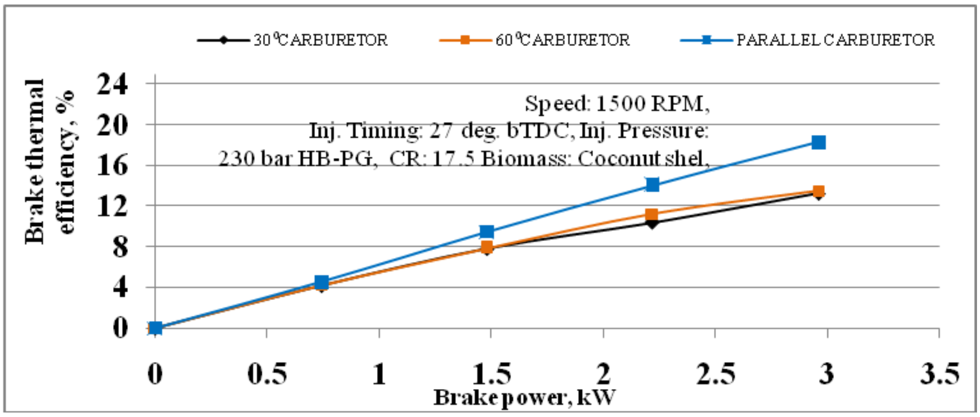

Figure 3. BP v/s BTE

The brake thermal efficiency (Figure 3) is found to be higher for HB-Producer gas operation over the entire load range with parallel carburetor. Producer gas being common, properties of the injected fuel has a major effect on the engine performance. The bio-diesel injected fuel has higher viscosity than diesel which makes atomization difficult and also has lower calorific value, resulting in lower brake thermal efficiency. Of all the carburetors, parallel gas entry carburetor gives better performance compared with 30° and 60° degree gas entry carburetors. The brake thermal efficiency HB - Producer gas operation for 30°,60° and parallel flow gas entry carburetors were found to be 13.29%, 13.49%,18.29% respectively.

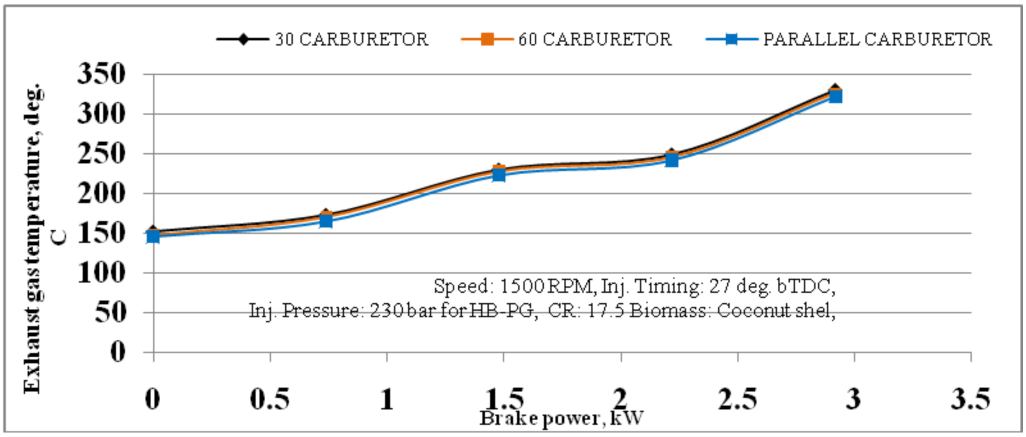

Figure4. BP v/s EGT

Exhaust gas temperature at different power outputs in dual fuel mode of operation is presented in Figure 4. The Exhaust gas temperature was found to be higher for HB -Producer gas with 30º carburetor. This could be attributed to incomplete combustion of gaseous fuel and injected biodiesel burns during diffusion combustion phase. Results showed that parallel carburetor gives lower exhaust gas temperature compared with other carburetors tested. The Exhaust gas temperatures at full load with HB - Producer gas operation for 30°, 60° and Parallel carburetors were found to be 330,326,322 degrees respectively.

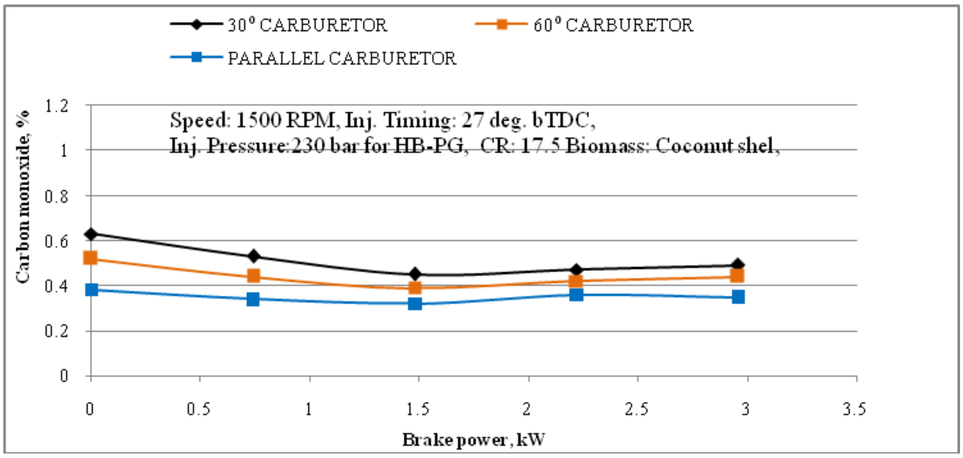

Figure5. BP v/s CO

The effect of brake power on CO emissions for HB-Producer gas dual fuel operation with different carburetors is shown in Figure 4. Higher concentration of CO in the exhaust is a clear indication of incomplete combustion of the pre-mixed mixture. The CO levels were found to be higher for dual-fuel operations due to already presence of CO in the producer gas and the associated combustion inefficiencies. Further Producer gas-air mixture supplied to the engine reduces the amount of oxygen resulting in incomplete combustion and increases the CO. At lower loads, the mixture being leaner results in greater extent of incomplete combustion and hence higher CO concentration. This puts a lower load limit for the dual fuel operation. At higher loads, the CO levels in the exhaust may slightly reduce because of increased combustion temperatures prevailing in the combustion chamber. Higher emission of CO levels in the exhaust could be attributed to lower heating value of Producer gas, lower adiabatic flame temperature and lower mean effective pressures. However, the CO emission levels were found to be lower with parallel carburetor compared to other carburetors tested. The CO emission at full load with HB-Producer gas operation for 30°, 60° and parallel carburetors were found to be 0.49, 0.44 and 0.35 respectively

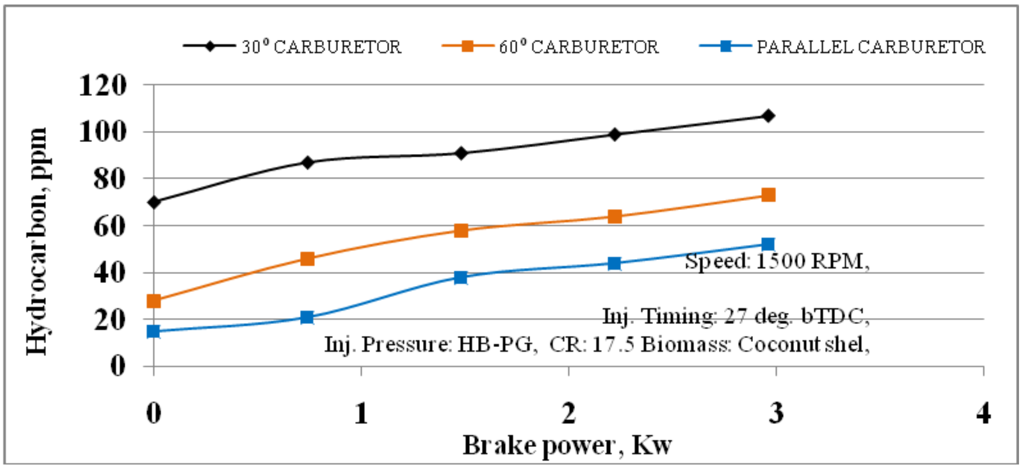

Figure6. BP v/s HYDROCARBON

The variation of HC emission levels with brake power is shown in Figure 5. The presence of free fatty acid and heavier molecular structure of the injected bio-diesel fuel compared to diesel results in higher HC emissions due to incomplete combustion. Parallel carburetor ensures supply of stoichiometric mixture of air and producer gas compared to other carburetors used and this ensures better combustion as well. The HC emission values at full load for HB-Producer gas operation with 30°, 60° and 60° carburetors were found to be 107, 73 and 52 respectively.

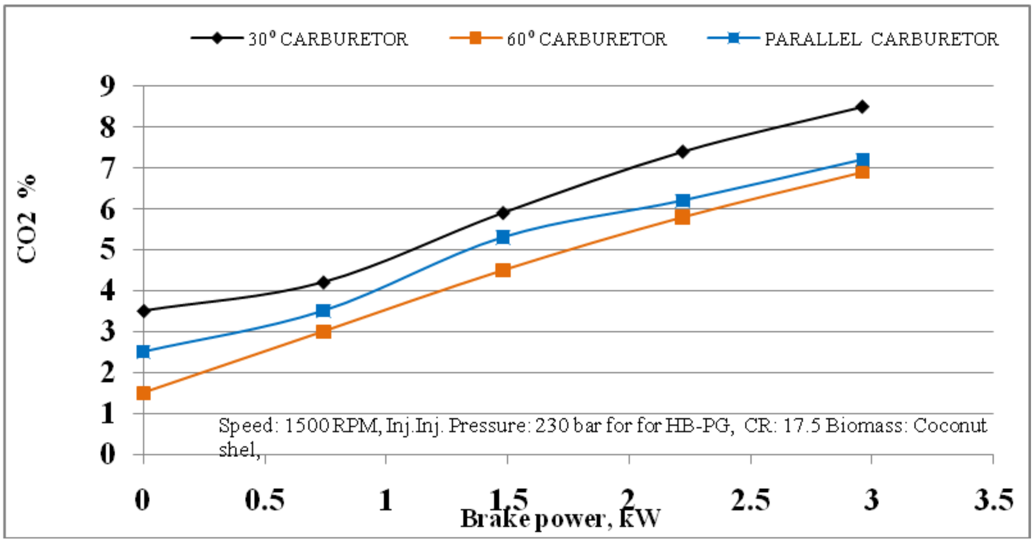

Figure7. BP v/sCO_2

The variation of carbon dioxide emission levels with brake power is shown in Figure 7. higher carbon dioxide emissions due to incomplete combustion and due to higher oxygen content in biodiesel. 60^0 carburetor ensures supply of stoichiometric mixture of air and producer gas compared to other carburetors used and this ensures better combustion as well. The carbon dioxide emission values at full load for HB-Producer gas operation with 30°, 60^0 and parallel carburetors were found to be 8.5,6.9 and 7.2 respectively.

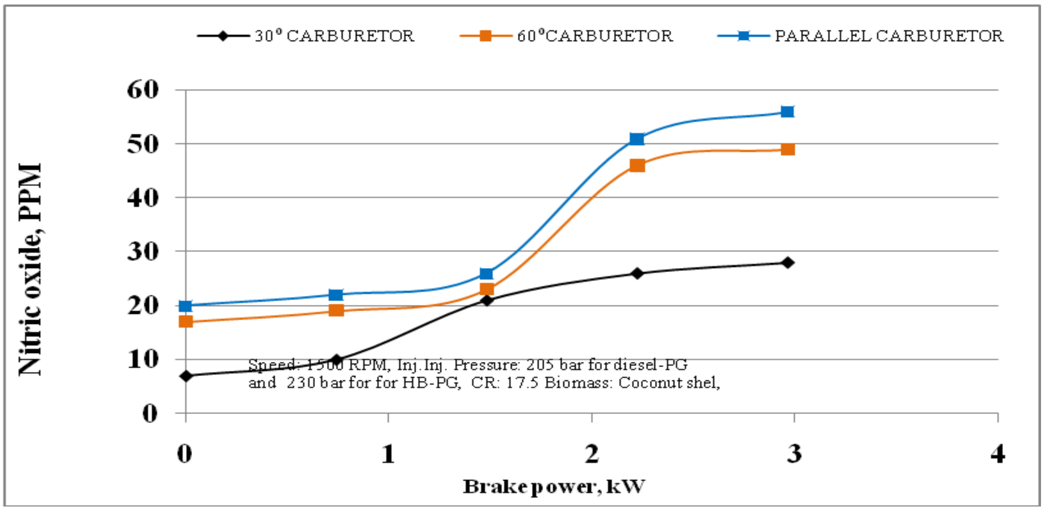

Figure8. BP v/s NO_x

The effect of brake power on nitrogen oxide emissions for HB-Producer gas dual fuel mode of operation is shown in Figure 8. The NOx emissions were found to be higher for HB-Producer gas over the entire load range FOR 30^0 and 60^0 carburetor. This is because the higher heat released during premixed combustion with HB- Producer gas dual fuel operation, results in higher BTE associated with higher NOx. Results indicate that parallel carburetor gives higher NOx compared with other carburetors because of higher heat release rates observed during premixed combustion. The NOx emission values at full load with HB - Producer gas operation for 30°, 60° and Parallel carburetors were found to be 28,49 and 56ppm for respectively.

Conclusion:

This paper investigates the influence of carburetor on dual fuel engine combustion process under real engine conditions. Optimizing air-gas mixer with an appropriate carburetor can significantly affect the performance of the dual fuel engine performance. HB-Producer gas with parallel flow carburetor is having batter effect on performance and emission characteristics as compared to other two carburetors.

On the whole it is seen that operation of the engine is smooth on Honne biodiesel–producer gas, dual fuel operation.

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