International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.3, Issue.1, Jan-Feb. 2013 pp-127-132 ISSN: 2249-6645

Experimental Investigation of IC Engine and Gassifier with Different Biomass Materials

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Abstract: *With recent price rise and scarcity of these fuels there has been a trend towards use of alternative energy sources like solar, wind, geothermal etc. However these energy resources have not been able to provide an economically viable solution for agricultural applications. Biomass materials are non-toxic, biodegradable, produced from renewable sources and contribute a minimal amount of net green house gases, such as CO_2, SO_2 and NO emissions to the atmosphere. Need of a suitable biomass material fuel for existing internal combustion engines is being desperately felt these days, when petroleum reserves are soon going to vanish from the surface of earth. Biomass fuel proposes one such option with its suitability as a replacement fuel for existing internal combustion engines, it becomes interesting to know performance of a dedicated IC engine with biodiesel fuel. Up to 50% Biomass material fuel blends in Gasifier can substitute wood without any modification in the engine. Hence, these blends of Vegetable waste may be considered as wood fuel substitutes.*

Key Words: *Biomass, Gasification, Wood, Vegetables waste*

I. Introduction

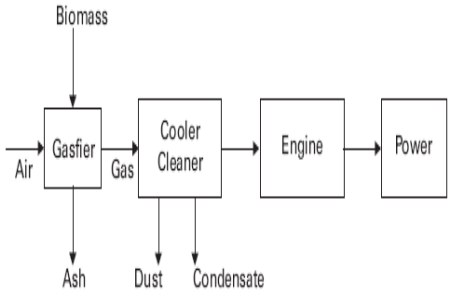
This study is relevant because efficient conversion processes are required for renewable resources in order to compare with fossil fuels. The topic is studied from a fundamental point of view with the help of thermodynamics. This comprises the first law, which states that energy can never be lost, and the second law, which states that the quality of energy will always degrade in irreversible processes. Biomass is thus regarded as a certain amount of work potential (that was previously fixed by photosynthesis), which decreases with every conversion step. The clue is to develop optimised processes, in which the work potential is largely retained, so that a high proportion of useful work is delivered. Gasification is a process that converts organic or fossil based carbonaceous material into carbon monoxide, Hydrogen, carbon dioxide and methane. This is achieved by reacting the material at high temperatures, without combustion, with a controlled amount of oxygen. The resulting gas mixture is called syngas or producer gas and is itself a fuel. Gasification is a method for extracting energy from many different types of organic material.

Vegetable waste pallets

Gasifier Model	Cosmo Cp-10
Mode of Operation (power mode)	Cold & Clean Gas
Gasifier Type	Down Draft
Rated Gas flow	25 m3/hr
Average gas calorific value	1000 k cal/m3
Gasification Temperature	1000-1200 degree centigrade
Ash removal	Manual, once every six hours.
Fuel type & Size	Wood/woody waste with maximum dimension not exceeding 25 mm & 25 mm dia.
Permissible moisture content in Biomass	5-20% (Wet basis)
Biomass charging	Online batch mode, by topping up once every two to four hours
Rated Hourly consumption	Up to 17 kg.
Typical conversion efficiency	> 75%
Typical gas composition	CO- 19%, H2-18%, CO2d-10%, CH4- upto 3%, N2-50%
Engine Genset	
Rated output (gross)	11 kWe
Rated output (net)	10 kWe
Specific Biomass Consumption	Less than 1.5 kg/kWhr

Vegetable Waste pellets are a type of fuel, generally made from compacted vegetable waste. The pellets are extremely dense and can be produced with a low humidity content (below 10%) that allows them to be burned with very high combustion efficiency. Pellets are produced by compressing the mixture of vegetable waste, wheat straw and cow dung which has first passed through a hammer mill to provide a uniform dough-like mass. This mass is fed to a press where it is squeezed through a Die having holes of the size required (normally 6 mm diameter, sometimes 8 mm or larger). The high pressure of the press causes the temperature of the vegetable waste to increase greatly.

Gasifier System for Power Generation



Experimental Setup

A downdraft gasifier of capacity 10KWe setup was installed in RGPV Energy Park to produce energy from various biomass materials. A three cylinder four stroke engine was purchased and installed with gasifier in Energy Park of Energy Department RGPV Bhopal to conduct experimental work for testing different biomass material fuels.

Procedure of experimentation

1. First start the water pump to fill water in tank. There should be sufficient water level in tank.
2. Fill the pieces of wood in gasifier chamber.
3. Give ignition to material in downdraft gasifier.
4. Initially the gas is exhausted to atmosphere.
5. Check the quality of gas by ignites a flame over gas.
6. If gas catches fire then take this gas in engine after cleaning.
7. Give self to engine.
8. After starting of engine check current and voltage on ammeter and voltmeter.
9. Give load when all conditions found normal.
10. This process continuously done for various fuels.

Technical Specification of Gasifier

A.C. Generator

Generator is a device which converts mechanical energy to electrical energy.A.C. Generator means Alternator; it consists of a Stator and a Rotor. The stator provides the armature winding whereas rotor provides the rotating magnetic field. When the Rotor is rotated by the prime-mover, the stator winding or conductor is cut by the magnetic flux of the rotor magnetic poles. Hence the EMF is induced in the stator conductors. The emf generated in the stator conductor is taken out from three leads connected to the stator winding.

Rating of Alternator

Rating	15 KVA
Phase	3
Pole	6
Connection	Star
AC Voltage	415V
Current	15A
Rotating speed	1500rpm
Ambient temperature	40 ^{0}C
Company name	Crompton Greaves Ltd

Results and Discussion

Repeated experimental work was done by using gasifier and three cylinder four stroke petrol engines and data was recorded. After collection of all data these data are represented in graphs & tables which are shown below

Subabool Wood Observation Table

S.No	Parameter	Value
1.	O_2	14.5 ppm
2.	CO	2632 ppm
3.	NO	85 ppm
4.	SO_2	49 ppm
5.	CxHy	4.82 ppm
6.	NOx	87 ppm
7.	Ta (^{0}C)	32.5^{0}C
8.	Tg (^{0}C)	574.1^{0}C
9.	Δt (^{0}C)	541.6^{0}C

Observation Table of Subabool Wood + Vegetable Waste Pallets (50%+50%)

S.No.	Parameter	Value
1.	O_2	13 ppm
2.	CO	7986 ppm
3.	NO	232 ppm
4.	SO_2	966 ppm
5.	CxHy	4.72 ppm
6.	NOx	239 ppm
7.	Ta (^{0}C)	34.8^{0}C
8.	Tg (^{0}C)	727.3^{0}C
9.	Δt (^{0}C)	692.4^{0}C

Engine Performance with Subabool Wood

S.No	Voltage	Amp	Frequency	Time	Consumption
1	420V	9A	50Hz	3.30 Hrs	20Kg/hr
2	420V	9A	50 Hz	3 Hrs	20Kg/hr
3	420V	8A	50 Hz	3.30 Hrs	20Kg/hr
4	420V	9A	50 Hz	3.30 Hrs	20Kg/hr
5	420V	10A	50Hz	4 Hrs	20Kg/hr

Engine Performance with Wood+ Pallets

S.No	Voltage	Amp	Frequency	Time	Consumption
1	420V	10A	50 Hz	4.30 Hrs	22Kg/hr
2	420V	10A	50 Hz	6 Hrs	22Kg/hr
3	420V	11A	50 Hz	6 Hrs	22Kg/hr
4	420V	12A	50 Hz	5 Hrs	22Kg/hr
5	420V	11A	50 Hz	6 Hrs	22Kg/hr

Calorific Value of subool wood=3540 Kcal/kg
Calorific value of vegetable waste pallets=2750 Kcal/kg
Calorific value of 50% Wood and 50%Vagetable Waste pallets= (3540+2750)/2 = 3145 Kcal/Kg

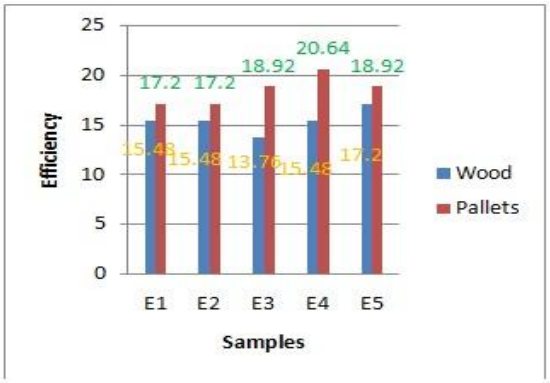
Mass of wood consumed in one hour=20 kg
Mass of wood+pallets consumed in one hour= 22 kg

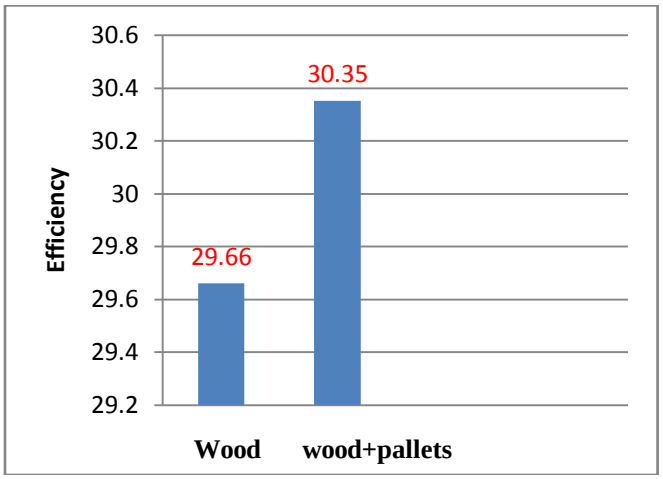
Power= mass x calorific value

Power input to gasifier with wood
P= 20 x 3540 =70800 kcal/hour = 82325.58 Watts
Power input to gasifier with wood+
Vegetable waste pallets (50%+50%)
P= 22 x 3145 = 69190 kcal/hour
= 80453.48 Watts
Flow of gas =21 Nm^3/Hour
Average calorific value of gas=1000 Kcal/Nm^3
Gasifier output Power= 21 x 1000=21000 Kcal/Hour
=24418.60 Watts
Efficiency of Gasifier with wood
=Power Output/Power Input
=24418.60/82325.58
=29.66%
Efficiency of Gasifier with wood+vegetable Waste Pallets (50%+50%)
= Power Output/Power Input
=24418.60/80453.48
=30.35%
Efficiency of engine with wood
Power input to engine= 24418.60 Watts
Specific Biomass Consumption=Power of engine/fuel consumed

Specific Biomass consumption with wood
=3780/19
=198.95 Watt/Kg

Specific Biomass consumption with wood+vegetable Waste Pallets (50%+50%)
=4536/23
=197.22 Watt/Kg





Conclusion

1. The temperature of producer gas with Wood is 574.1^{0}C and with wood + pallets is 727.3^{0}C. This indicates that a wood+ pallet is a better fuel then Subabool wood.
2. The efficiency of gasifier with wood is 29.66% and with wood + pallets is 30.35%. This shows that wood+pallets are a better fuel then Subabool wood.
3. Efficiency of engine with wood+vegetable waste is more so we can use vegetable waste with wood as a gasifier fuel.
4. Specific fuel consumption is less when we use wood+vagetable waste as fuel.

Future Scope

1. Analysis of composition of exhaust emission can be done with prolonged service with biomass material.
2. Performance of engine can be compared for various blends of biomass material. Present study is focused only to blend Subabool wood and vegetable waste biomass material.
3. By computation analysis performance parameters can be extrapolated and compared with experimental results.
4. Design changes can be studies and can be proposed after studying the problems encountered after prolonged service of engines with this biomass material fuel.
5. Emission studies can also be done.
6. Content of poisonous gases in producer gas can be reduced.

Social Benefits

1. This improves rural economy and employment through Biomass supply.
2. The plant will also encourage the concept of energy plantation thus resulting in greener environment resulting in more rainfall and reduction in ambient temperature.
3. The costs of installation per kWe are about the same as for large power levels (of the order of hundreds of MWs) and the plant load factor is about the same as for large thermal power plants.
4. It improves the country's energy self-reliance and reduces the crippling oil import bill and saves enormous foreign exchange.

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