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Analysis of Producer Gas Generated From Open Top Fixed Bed Downdraft Gasifier

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ABSTRACT:

Using biomass gasification to produce combustible gas is one of the promising sustainable energy options available for many countries. At present, a few small scale community based power generation systems using biomass gasifiers are in operation in Sri Lanka. However, due to the lack of proper knowledge, these systems are not being operated properly in full capacity. This stands as an obstacle for further expansion of the use of gasifier technology. The objective of this study was to identify the most influential parameters related to fuel wood gasification with a down draft gasifier in order to improve the gasification processes. A downdraft gasifier of 10kW electrical capacity was used to study the effect of equivalent ratio (Actual air fuel ratio to Stoicheometric air fuel ratio: ER) on the specific gas production, the heating value of gas produced and the cold gas efficiency using three throat diameters (125mm, 150mm and 175mm). Six trials were carried out for each throat diameter by varying the supply air flow to change the ER. The gas samples were tested for their compositions under steady state operating conditions. Using mass balances for C and N, the cold gas efficiencies, calorific values and the specific gas production rates were determined. The results showed that with all throat diameters the calorific value of gas reduced with the increase of ER.

INTRODUCTION

1.1 Introduction to Biomass:

Day to day petroleum products are exhausted. Petroleum demand in the Asia-pacific countries keeps on growing, particularly in china with its significant economic development and in India where a demographic factor is also at work. As a result, the world petroleum supply and demand balance is becoming increasingly tight by the day, and being cited as one of the factors causing the recent soaring oil prices. It is a non renewable energy source. Petroleum reserves are concentrated in some regions of the world like Gulf countries and these are not equally distributed in all countries. so, these are importing petroleum from the other countries to meet their energy needs. But because of the continuous increase in the demand for petroleum products they are not meeting their energy requirements. so, they will go for the alternative fuel source for their energy security.

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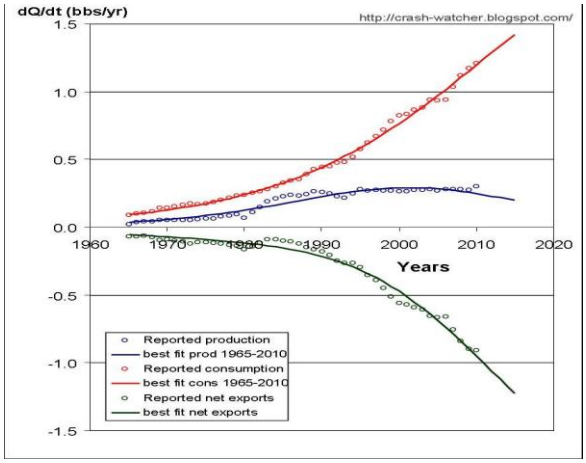

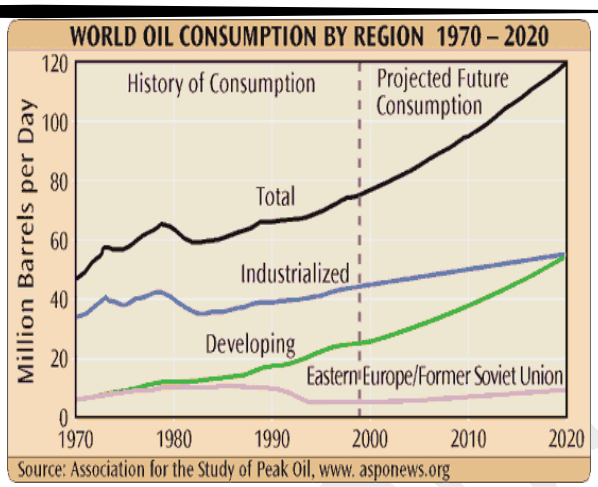

Fig 1.1 India's oil production and consumption 1960-2020*

Fig 1.2 world oil consumption

Petroleum purely contains HC mixtures and carbon dioxide. Perfect combustion is not possible with petroleum. It will lead to the generation of CO, H2etc and at high temperatures the formation of NOX also takes place. Because of the absence of inbuilt oxygen it will lead to the environmental pollution. According to the future needs, consequences and based on environmental pollution, we have to go for the environmental friendly resource like biomass which can substitute petroleum products fully or partially.

Biomass is a localised fuel and renewable energy source. A Cheap, abundantly available fuel. Bio-fuel has been a source of energy that human beings have used since ancient times. It can be easily transferable and storable. Age-old and most widely used fuel source. Bio-fuels are being investigated as potential substitutes for current high pollutant fuels obtained from conventional sources because it has inbuilt oxygen (environmental friendly). Annual consumption was estimated to be of the order of 20 million tonnes a few years ago. A very Clean fuel since biomass has no Sulphur content. Biomass energy has the potential to supply a significant portion of America's energy needs while revitalizing rural economies, increasing energy independence and reducing greenhouse gases.

Table 1.1:Power Potential over All Agricultural Crops in India

State	Crop Area KHa	Residue generation KT	Utilization KT	Excess Biomass KT	Power MW
Uttar Pradesh	24136.50	100648.23	76287.10	24361.13	2919.44
Punjab	6877.30	49972.08	27940.87	22031.20	2539.8
Madhya Pradesh	19309.40	44749.66	33238.04	11511.62	1423.42
Tamil naidu	14827.20	45172.46	29963.43	15209.03	1357.64
Rajasthan	15518.80	34056.38	23688.09	10368.30	1294.28
Haryana	4948.50	27493.47	17526.88	9966.59	1171.67
Karnataka	8068.20	24597.81	16107.87	8489.94	1096.69

Gujarat	8424.20	29363.60	22317.15	7046.45	880.63
Bihar	8971.50	29013.30	22809.52	6203.79	710.35
Andhra Pradesh	11963.80	37157.02	31685.38	5471.64	648.98
Kerala	1604.00	8477.05	3546.07	4930.99	639.80
Maharashtra	12672.80	27834.04	23244.70	4589.34	570.14
West Bengal	7912.90	35139.22	30503.12	4636.10	558.60
Assam	3235.20	10069.35	8886.27	1183.08	137.35
Orissa	5211.20	10136.16	8944.56	1191.59	133.65
Meghalaya	205.30	646.94	547.00	99.94	11.08
Arunachal Pradesh	188.40	381.08	339.33	41.75	5.08
Sikkim	61.40	149.49	132.28	17.21	2.21
Mizoram	10.50	43.41	38.68	4.73	0.62
Total	154147.36	515100.76	377746.32	137354.43	16101.21

A lot of research is done, around the globe the drastic depletion of fossil fuels and increase in vehicular population has renewed interest of scientific community to look for alternative fuels like bio-diesel, solar, wind, wave power,H2 etc. Biomass & bio-diesel are cheap compared to the other alternative fuels and these are abundantly available. Bio-diesels are derived from edible &non edible vegetable oils, which may be used for cooking or for medicine. Biodiesel derived from non-edible oil is considered as a better substitute for fossil diesel in diesel engine.

In India, biodiesel is costly and hence, fumigation of cheaper gaseous fuel is one of the ways of reducing the operating cost of the biodiesel fuelled diesel engine and to promote the use of biodiesel in commercial scale. So we can go for the 3rd generation of biomass like algae etc. Biomass is generally two types based on its availability in natural form.They are woody and powdery type. Woody biomass is having density larger than about 200 kg/m3 and ash content limited to about 2%.Powdery biomass is having density in the range of 50-150 kg/m3 and ash content is upto 20%.

ANALYSIS

By considering the literature review we fabricated the biomass gasifier and it is successfully operated to generate Producers gas. The fabricated gasifier is provided with testing facilities like variation of speed of blower, which results in variation of suction pressure. It is also provided with an air box with a U-tube manometer so that one can measure the flow of air in the gasifier chamber and the air is mixed with the Producer gas for the purpose of burning at the gasifier burner. The other modification one can do by changing the size of biomass chip and changing of entire biomass.

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After the preparation of gasifier the chips from "KAMBA" wood considered for the gasification process and the gasifier is operated with gradual raise in the temperature of oxidation zone. At low temperatures the rate of generation of Producer gas is very low. It may due to the low oxidation region existence. On continuous flow of air through the gasifier the oxidation zone gradually increased as a result the temperature increases too. When the temperature in the range of 700-1000oC the production rate of gas is higher.

The production rate of gas is also depends on the flow velocity of the air at the speed of 2500 rpm(when the blower is operated at 100V).The generation of hydrocarbons very significant and it is around 700 ppm. The production rate of CO will not subjected to sudden changes but it is hovering around 1.2%.These HC and CO values are very harmful to the environment but these are participated in the oxidation as a result they changes into CO2 and H2O .

The generation of Producer gas also depends on the distance in between oxidation zone and gas outlet point from the gasifier chamber. When these two are nearer there is no production of gas, simply it generates CO2.When the distance in between these two if it is increases and if the oxidation zone is nearer to the top of the gasifier will results in the reduction of drying zone so that the rate of production of gas also reduces. In between these two extreme limits we found that when the distance in between oxidation zone and gas collection point if it is 1 feet (approximately) it is favourable to generate gas.

The generation of gas also depends on the size of biomass as well as purity of biomass. If along with the biomass chips any fine particles of wood like sawdust is placed inside the gasifier chamber it caused for choking of air. It leads to increase of sucking of fresh air from the bypass. In the gasification oxidation is the surface reaction i.e, the generation of Producer gas starts from the outer surface of the biomass chip and moved towards the coal so that the size of chip should be favourable to allow the air through all the biomass chips which leads to accelerate the generation of Producer gas.

During the experimentation another observation is production of considerable quantity of water as well as tar. The rate of production of water directly proportional to the moisture content in the wood. By increasing the dryness one can reduce the formation of water. The other reason for formation of water inside blower casing is chilling effect i.e, the contact of

vapour with the low temperature surface leads to the condensation of vapour. The prolysis process is a carbonization process i.e, the water vapour present in the air as well as in the biomass both are passing through burnt carbon products and it generates gummy like substances which we call as tar. It can be reduced by using proper heat exchanger.

In our experiment, even though our final goal is to implement over the diesel engine as a fuel, at the initial stage we burnt the gas at the outlet of the pipe which is connected with outlet of the blower. Whenever such type of burning is designed the proper mixing of air and the gas is required. It leads to homogenization and premixed burning. But if the mixing of air and gas is not proper it may leads to diffusion burning. For proper burning we consider a burner at the outlet pipe.

From the above discussions one can identify different parameters which influences the generation of producer gas as well as it gives an idea about how to fabricate a gasifier for the effective generation of Producer gas.

SPECIFICATION

1. Blower

   Power - 1 H.P

   Speed - 2800 rpm

   Supply - 230 volts

2.Gasifier chamber

   Bore - 11 cm

   Height - 75 cm

3. Valves

   2 gate valves - 1 inch

   2 ball valves - 1 inch

4. Pipes - 1 inch

5. Pipe - 5 inch* 1 inch

6. Air inlet

7. Filter

8. Burner

9. Dimmerstat (240v,1Φ,50Hz)

CONCLUSION

The detailed CFD model of an up-draft gasifier has been developed, based on fluent package. Models of finite rate chemistry in the gas phase and char reactions have been added to the standard model. Simulation performed to predict the gas composition for varying air velocity, fuel rate and moisture content.

1. The simulation result shows that, as the air velocity increases, the value of H2 firstly increases from 14% to 21% then decreased and CO concentration first decreased from 25% to 19% then increased. because at one optimum point the air velocity so high that causes on that point gasification not proper done and the value of H2 decreases and CO increases.CO2 concentration increased from 10% to 19% because of large amount of element C react with O2 and produce CO2.AndThe Maximum value of H2 is 21% is obtained at air velocity of 5.4 m/s.

2. When increasing fuel rate, concentration of H2 and CO2 decreased from 24% to17% and 17% to 13% respectively then increased by increasing the fuel rate and the concentration of CO first increased 18% to 22% then decreased 20% to 16%. Because the air is not enough to gasification that reason the temperature of bed decreased. For decreasing bed temperature value of H2 start to increase and CO start to decreased. So the optimum value of fuel rate is 8.8 kg/h.

3. When increasing the moisture content in gasification, the value of H2 first increased from 15% to 24% then decreased because the level of moisture contents so high. And the value of CO first decreased 37% to 31% and then increased 31% to 41%.And the CO2 concentration increasing gradually. So the optimum value of moisture content is 25%.

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