Research Paper

Volume : 2 | Issue : 5 | May 2013 • ISSN No 2277 - 8179

Performance and Development of Down Draft Gasifier: a Review

Engineering

KEYWORDS :

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ABSTRACT

In this era of convectional fuel shortage that why now a day prices is increase, so gasifier may good device for industries and power generation. Common Heating system is applied based on wood, fuel, electricity, coal/ lignite in some industries. Some of the limitation of these systems are environmental pollution, poor process control and cost. On the other hand biomass gasifier technology offers good efficiency, process controllability economics viability and environmental accessibility. Think of the 18 000 Indian villages that will continue to be without electricity for at least the next 10 years. Though they fall under the government's rural electrification programme, it is not feasible at present to connect them to the grid. Then, there are other 62 000 villages that are still waiting to be wired and in villages that are already wired, supply continues to be erratic. To electrify rural India so as to usher in development uniformly is an uphill task.[15]

1. Introduction

Wide variety of conversion technologies is available for the production of premium fuels from biomass. Conversion process generally depends on the physical condition of biomass and the economics of competing process.

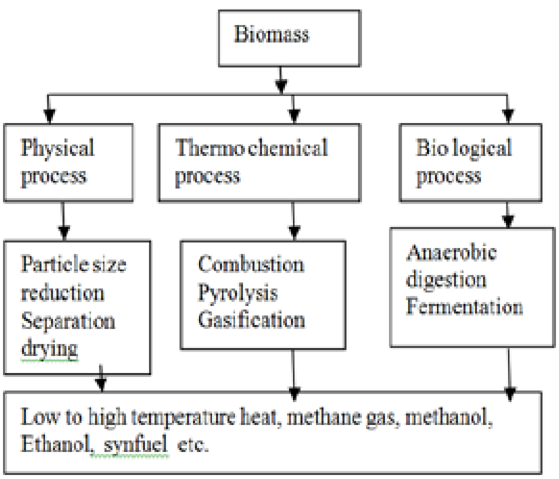

Figure 1 – Biomass to Energy conversion classification[1][3][10][5]

Biomass conversion technology can be basically grouped into three categories. (1) Direct combustion (2) Thermo-chemical conversion (3) Biochemical conversion. [3][4][10]

In the gasification process, solid biomass is broken down to produce a combustible gas by the use of heat in an oxygen-starved environment. Heat for gasification is generated through partial combustion of the feed material. The resulting chemical breakdown of the fuel and internal reactions result in a combustible gas usually called "producer gas"[10].This gas can either be used to produce mechanical or electrical, heat.

2. DOWN DRAFT GASIFER CONCEPT

In downdraft gasifiers, air enters at the combustion zone and the gas produced leaves near the bottom of the gasifier. Gas and airflow are basically downwards, but free conversion and conduction heat the upper pyrolysis zone. In this type of gasifiers, the volatiles and the tar produced from the descending moving bed have to pass through the reduction zone where mostly they are cracked and gasified by means of steam and carbon dioxide.

3. CHEMISTRY OF GASIFICATION

In a gasifier, the carbonaceous material undergoes several different processes like drying, pyrolysis, combustion, gasification processes. The dehydration or drying process occurs at around 100°C. Typically the resulting steam is mixed into the gas flow and may be involved with subsequent chemical reactions, notably the water-gas reaction if the temperature is sufficiently high enough. Pyrolysis (or devolatilization) process occurs at around 200-300°C. Volatiles are released and char is produced, resulting in up to 70% weight loss for biomass. The process is dependent on the properties of the carbonaceous material and determines the structure and composition of the char, which will then undergo gasification reactions. Combustion process occurs as the volatile products and some of the char reacts with oxygen to primarily form carbon dioxide and small amounts of carbon monoxide, which provides heat for the subsequent gasification reactions. The basic reaction here is[13]

$$C + O2 \leftrightarrow CO2 \quad (1)$$
$$\Delta H = -393.5 \text{ kJ/mol}$$

Gasification process occurs as the char reacts with carbon and steam to produce carbon monoxide and hydrogen, via the reaction

$$C + H2O \leftrightarrow H2 + CO \quad (2)$$
$$\Delta H = 131.3 \text{ kJ/mol}$$

In addition, the reversible gas phase water gas shift reaction reaches equilibrium very fast at the temperatures in a gasifier. This balances the concentrations of carbon monoxide, steam, carbon dioxide and hydrogen.

$$CO + H2O \leftrightarrow CO2 + H2 \quad (3)$$
$$\Delta H = - 41.1 \text{ kJ/mol}$$

The first step to initiate the combustion process is heat the fuel particles up to the temperature required for combustion process, which is determined and validated by various authors. Due to the limitation of the present CFD codes, it is generally assumed in all studies that the heat required to initiate the combustion of biomass/RDF particles is provided by the fluidizing air entering at the combustion temperatures.[14]

4. LITERATURE REVIEW

Mukunda et al. (1994) developed an open core gasifier consisting of a vertical tubular reactor. Water seal at the bottom. Lower two-thirds of the reactor was lined with ceramic materials to prevent high temperature corrosion. They reported that producer gas used for engine applications. It contained low amount of tar. Composition of gas was 18% H_2, 19% CO, 1.25% CH_4, 12% CO_2, 50% N_2. Calorific value ranged from 4 MJ/kg to 4.4 MJ/kg.Tar and particulate matter 100 mg/m3 to 700 mg/m3.[2]

Chuangzhi Wu et al. (1997) In this study, experimental data from a 1MW circulating fluidized-bed (CFB) biomass gasification and power generation plant constructed in 1998 were analyzed; and it was found that the unit capital cost of BGPG is only 60 to 70 percent of coal power station and its operation cost is much lower than that of conventional power plant.[3]

Jain (2006) designed and tested 5 open core throat less rice husk gasifier. Internal diameters 15.2, 20.3, 24.4, 30.3 and 34.3 cm,Best specific gasification rate of around 200 kg/hr-m2 Equivalent ratio - 0.40 , Gasification efficiency - 65%, Lower heating value - 4.5 MJ/Nm3.[8]

These parameters can be used for designing rice husk operated throat less gasifier in the capacity range of 3 to 30 kW.

This review reports the state of the art in modeling chemical and physical processes of wood and biomass pyrolysis. Chemical kinetics are critically discussed in relation to primary reactions, described by one-and multi-component (or one-and multi-stage) mechanisms, and secondary reactions of tar cracking and polymerization.[9]

Ambani Jaydeep D, Dafda Jayesh M. (June 2010) Developed and open core throat less downdraft biomass gasifier reactor mainly consists of two concentric cylinders. The inner cylinder will work as reactor and outer cylinder, called containment tube, works as the heat exchanger.

Table-1 Energy equivalent of the calorimeter and calorific value of Biomass [12]

Sr no.	Calorific value of cotton stalk, cal/ g	Weight of water, ml	Energy equivalent, cal / °C	Weight of sample, g	Temperature rise, C	Correction factor	
						Nichrome wire(E1), cal	Cotton thread (E2), cal
1	4047	2000	348	0.99	1.81	1.40	213

Table-2 Parameter of open core throat less downdraft gasifier [12]

1	Fuel consumption	6.3 kg/h
2	Quantity of gas produced	15.22 m3/h
3	Volume of reactor	0.0504 m3
4	Area required	0.0315 m2
5	Diameter of reactor	0.0225m
6	Height of reactor	1.29m

5. MODEL OF GASIFIER DETAILS

An open core throat less downdraft biomass gasifier reactor mainly consists of two concentric cylinders. The inner cylinder will work as reactor and outer cylinder, called containment tube, works as the heat exchanger. Both the cylinders are made from 3 mm thick Mild Steel sheet. Diameter of inner and outer cylinder is kept as 225 mm and 325 mm as per the design. The length of inner reactor and outer containment tube is kept 1410mm and 1690mm as per the design.[12]

Figure-2 Model of Gasifier [12]

It is a throat type gasifier reactor and the combustion of the fuel is occurred near the throat.

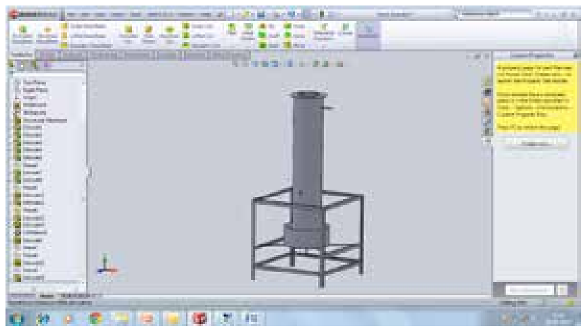

Figure-3 Isometric Model of Gasifier

The fire port is provided on the side of the throat and limited amount of air is allowed to enter in the reactor from this port. The producer gas is sucked from the reduction zone just below the combustion zone occurring near the fire port area.

6. FUTURE WORK

From the as above related literature down draft gasifier design by Agriculture University. Based on this Experimental data using Ansys software to analysis to improve a gasifier performance by changing design parameter. There are many parameters which effect to performance of gasifier. By using this software getting maximum optimization.

7. CONCLUSION

From the above literature survey it may be concluded that without analysis of gasifier in Ansys, it is difficult to optimize design Parameters like gasifier diameter, length, and gap between a two tube (inner and outer tube). So CFD Analysis is a good tool to replace costly and time consuming experimental work.Thus it should be maximum optimization in easiest way.

ACKNOWLEDGEMENT

We gratefully acknowledge Mechanical engineering department of RK University for technical support. Also the thanks to Ambani Jaydeep D.,Dafda Jayesh M. And Kunjadia Rashmin for always for providing help and moral encouragement.

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