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Review article: RECENT TECHNOLOGIES

Proximate and ultimate analysis of Cotton pod used in the updraft gasifier - A review

G. GowriShankar[1]

Abstract: Gasification is the process in which a solid carbonaceous fuel is converted into combustible gas using partial amount of air. The gases which evolve are known as "producer gas". This gas is more suitable than the direct combustion of biomass. Gasification involves partial combustion of the organic part of the fuels to combustible gas in carbon monoxide, hydrogen and some saturated hydrocarbon gases, principally methane. In this paper an updraft gasifier is constructed and is used to carry out the experiment. The waste material like cotton pod is used for the generation of producer gas. The main objective of the present study is to investigate many aspects of cotton pod as a potential energy source, including major properties and characteristics of cotton pod and way to evaluate cotton pod.

Keywords: Extinguisher, Fire safety, Ball type Extinguisher

1. INTRODUCTION

The fossil fuel has high energy density compared to the biomass. Its bulkiness and inconvenient form of biomass is the major problem for utilization. Handling, storage, and transportation of biomass is more costly compared to conventional fuel. One of the easy ways to handling the biomass is converting solid biomass into liquid or gaseous fuel. This conversion will be achieved by the two ways biochemical and thermo chemical. Some Chemical reaction, heat, mass transfer and pressure changes are the complex process involving in biomass gasification. The gasification process involved are drying, pyrolysis, combustion ,reduction [1].wood and other form of biomass including energy crops and agricultural and forestry wastes are some of the main renewable energy resources available. Combustion: it is commercially available technology and minimum risk to investor's. It is used for immediately heat and power generation. Heat storage is not a viable option in the combustion process. Gasification: in the process biomass produce the fuel gas or producer gas with the mixture of carbon monoxide, carbon dioxide, hydrogen and methane. pyrolysis: it is the thermal decomposition process with absence of oxygen .it also one of the process in the gasification [2].the biomass fuels which have a different moisture contents, less than 50% produces the gaseous fuel in the pyrolysed with absence of oxygen. The biomass gasification technology is expected to play an important role in the future development of energy system. Based on the gasification medium the biomass gasification can be classified air, steam, air-steam mixture and oxygen-steam mixture these are main gasification agent used in the gasifiers. Basically air is used as the working medium for the producer gas and it has low heating value around 4000-7000 KJ/NM^2. The pure oxygen result is highest quality gas around 10000-18000KJ/NM3 [3]. Thermo chemical gasification of biomass has been identified as a possible system for producing renewable hydrogen [4]. Biomass fuel such as wood, agricultural by products are the currently form world's third largest primary energy resources after coal and oil. Pyrolysis or release of volatiles and conversion of the residual char are the two overlapping stages in gas production in biomass.[5].

Department of Information Technology, Dr. N. G. P. Institute of Technology, Coimbatore, Tamil Nadu, India

2. BIOMASS GASIFICATION PROCESS

In the gasification process the partial thermal oxidation takes places and also produce a gas products co2, water, carbon monoxide, hydrogen and gaseous hydrocarbons and also produce the small quantities of tar and ash based on the steam, air or oxygen supplied[6].

The gasification process consists of the following stages:

1. Drying: Moisture content in the biomass should be in the range of 5% to 30%. It should be reduced into 5% due to the temperature range from 100-200°C.
2. Pyrolysis: Thermal decomposition of the biomass with the absence of oxygen or air. Volatile matter in the biomass is reduced into hydrocarbon gases and also the biomass converted into solid charcoal.
3. Oxidation: In the oxidation process carbon-dioxide will be formed due to the reaction between the solid carbonized biomass and oxygen in the air and the hydrogen oxidized are generate water. Hydrogen will

oxidized and produce the large amount of heat. Partial oxidation of carbon may occur resulting in the generation of carbon monoxide.

4. Reduction: These reaction are mostly endothermic the temperature range between 800-1000°C with the absence of oxygen. several reaction are given below [7 - 8].

3. BIOMASS CHARACTERISTICS

3.1. Particle size

Heat transfer should be better when the biomass size will be smaller and also the temperature will be uniform[9]. The particle size of the biomass material depends on the hearth dimension .it is typically 10-20% of the hearth diameter. Large particles can form bridges. While smaller particles are clog the available air void age and leading to a high pressure drop. Biomass pre-processing phase have a major impact on gasification outcomes. Based on the size of the biomass the behavior will be differently in the process [10].

3.2. Moisture content

Below 15% of moisture content is required are otherwise the more energy is required for gasification reaction. Moisture content above 30% makes ignition difficult and reduces the CV of the gas due to the need to evaporate the additional moisture before gasification can occur. A high moisture content reduces the temperature achieved in the oxidation zone, and also incomplete cracking of hydrocarbons released from pyrolysis zone. Increased levels of moisture content and the presence of CO produces H_2 by the water gas shift reaction and in turn the increased hydrogen content of the gas produces more CH_4 [11].

3.3. Ash content

The gasification is impossible when the mineral matter will be high. The oxidation temperature is often above the melting point of the ash, leading to clinkering or slagging problem in the feed and hearth. Clinker is a problem for ash content it may be above 5% the ash is high in alkali oxides and salts. [11 - 12].

4. PROCESS PARAMETERS AND THEIR EFFECTS

Its affect the various performance aspects like efficiency, product gas quality, energy and energy inputs. Such as temperature and heating rate on the composition of the products and temperature changed. Addition of catalyst particle changed the selective of gasification reaction enhancing hydrogen production while reducing the level of methane produced at temperature of above 500°C [13].

4.1. Heating Rate

Fast pyrolysis the temperature rates of up to 1000°C /min at and low temperature below 650°C and with rapid quenching the liquid. in the high heating rate the char formation will be reduced[2]. Practical technology must convert the biomass into cellulose, hemicelluloses, lignin, protein and extractive components of a biomass feedstock into a gas rich in hydrogen and carbon dioxide and amount of tar and char are formed. In the bed low temperature and high feed concentrations, char formation occurs[14]. Cellulose, hemicelluloses, lignin are the major components of wood[15].

4.2. Equivalence ratio

Equivalence ratio strongly affected the gas composition including the tar content these is ratio between the oxygen content in the oxidant supply[16]. The ratio between the theoretical and practical air demand in steam gasification process utilizing air or O_2 is termed the equivalence ratio (ER). For each kind of biomass, there is a theoretical O_2 demand needed to achieve the combustion based on its contents of combustible materials. High ER decreases the H_2 production and increases the CO_2 output. increasing the equivalence ratio resulted in lower pressure drop in the dense bed when the gasifier operated at different fluidization velocities and bed heights[17].

5. EFFECT OF GASIFICATION AGENT

Biomass like (cotton stalk, ground nut shell)can be gasified using different gasifying media, the choice depends on the product gas composition and energy consideration. In Gasifier generally use steam or air. Air gaification is an exothermic process which produce a low heating value in CO and having small amount of H_2 and higher hydrocarbons. Steam gasification on the other hand is an endothermic processes, which produce a medium heating value gas in H_2 and CO. used air steam mixture in the gasification process in fluidized bed reactor. Steam to air ratio on char was particularly strong at small ratio due to the fact that the steam released at the devolitization stage contributed to the gasification process even in the case when steam was added. the steam-air ratio increased the heating value was increased and reached its peak value[18]. Investigated the effect of air to steam ratio on the gasification of wood shavings. An increase in the steam flow rate resulted in lowering the gas yield, the heating value and the energy recovery, although the reactor was heated from outside which helped to keep the temperature constant without any adjustment of the flows[19][20].

5. EFFECT OF TURNDOWN RATIO

Turndown is the ability of the gasifier to respond to the changes in the demand for the product gas with different capacity and also the same time, operated with a stable reaction zone. Turndown is often quoted in the trade leafletsgasifier, but most of these are ambiguous. It was observed that turndown ratio goes up almost linearly with the increase of the capacity of the dry fuel as well as the amounts of the produced gas and combustible gas[21].

6. EFFECT OF TEMPERATURE

The different range of temperature in the gasifier affects on the reaction rate and the composition of the product; reduction in CO, CO_2, and CH_4 occurs, and more H_2 produced with increasing the temperature .the char conversion decreases with the temperature increase. Thus the gasification temperature is needed to be selected carefully as a tradeoff between the char conversion and the H_2 output. that high H_2 yield can be obtained at low temperature (600oC) by using 90% steam content[22].

It is necessary to ensure that the product gas is free of any solid carbon. As temperature increase, carbon and methane both are reformed. In 726 °C both are reduced to very small amount and in the process get converted into CO and H_2. Increase in hydrogen mole numbers. At 756 °C, the hydrogen yield reaches a maximum values in moles. At higher rate of temperatures the H_2 yield starts reducing. This is attributed to the water gas shift reaction[23].

In most chemical reactions, the rate of gasification is highly dependent on the temperature .the product gas yield in the flash pyrolysis of maple saw dust increased as the reactor temperature increased whereas the liquid and solid products decreased with increase in the pressure. The decreasing the amount of the char indicated that the conversion increased with increase in the temperature. 10 % and 50% basis conversion of the lignin at 350 and 450 °C, respectively it was attained[24].

Tars are normally produced during the pyrolysis stage in low temperature. It decrease in the tars content from 6290 mg/Nm3 dry gas at 740 °C to 412 mg/Nm3 at 850 °C of the producer gas with increase in the temperature during air gasification of beech wood. found that the tar content of the gas from steam wood gasification is decreased from 3.17% at 504 °C to 0.58 % at 780 °C[25].

7. EFFECT OF PRESSURE

Simulation carried out to study the effect of reducing pressure below 101.3KPa on equilibrium product yield showed that increase in H_2yield is negligible even for pressures as low as 10.13 KPa. Pressure has been reported to have a significant effect on the gasification processes[26]. The first order rate constant for the char gasification increased with increase in the pressure. The role of increased pressure has been investigated on the equilibrium percentage of various species in the dry gas, char, and calorific value of the gas, gasification efficiency, outlet gas temperature and heat absorbed in the reduction zone. It follows that the percentages of CO and H_2 decrease as the pressure increases while the CH_4, CO_2, N_2 and unconverted char grow with increasing the pressure[27].

8. PROXIMATE ANALYSIS

The proximate analysis gives the moisture, the volatiles, the fixed carbon and the ash contents in the biomass fuel. From the analysis, the quality of biomass fuel for usage in the gasifier is determined. The significance of the volatiles and fixed carbon is that they provide a measure of the ease with which the biomass can be ignited and subsequently gasified or oxidized, depending on how the biomass is to be utilized as an energy source For example, a volatile content of the wood of about 80% is higher compared to a charcoal with volatile content of only 30%. This is good for initiating the combustion in the oxidation zone but too high means creating problems associated with tar formation because the formation of tar is proportional to the volatile content [28].

8.1. Moisture Content

The heating value of the gas produced by any type of gasifier depends at least in part on the moisture content of the feedstock. Moisture content can be determined on a dry basis as well as on a wet basis. Accurately measured 1g of the fuel samples was measured and dried in an muffle furance at a temperature of 105°C for one hour. The following data was obtained from the test [29].

Weight of the cotton pod before drying in the oven. Weight of the cotton pod after drying in the oven. The moisture content of the cotton pod on the wet basis is defined as

$$MC_{wet} = \frac{wet\ weight - dry\ weight}{wet\ weight} \times 100$$

The moisture content of the cotton pod on the dry basis is defined as

$$MC_{dry} = \frac{100 \times MC(wet)}{100 + MC(wet)}$$

8.2. Volatile Matter

Accurately measured 1g of the fuel samples was measured and dried in an muffle furnace at a temperature of 950°C for 7 minutes. This indicates that all volatile matter has been driven off. After this, the weight of the heated samples was taken [30].

Weight of the cotton pod before placing on hot plate.

Weight of the cotton pod after heating on the hot plate.

$$VM = \frac{Weight\ intial - Weight\ final}{Weight\ intial} \times 100$$

8.3. Ash content

Accurately measured 1g of the fuel samples was measured and dried in a muffle furnace at a temperature of 500-600^{o}C for two hours, the weight of the samples was taken, and given as follows:

Initial weight of the cotton pod before placing on hot plate [31]. Final weight of the cotton pod after heating on the hot plate.

$$Ash = 100 - \frac{initial\ weight - final\ weight}{initial\ weight} \times 100\%$$

Ashes can cause a variety of problems particularly in up or downdraught gasifiers. Slagging or clinker formation in the reactor, caused by melting and agglomeration of ashes, at the best will greatly add to the amount of labor required to operate the gasifier. If no special measures are taken, slagging can lead to excessive tar formation and/or complete blocking of the reactor. A worst case is the possibility of air-channeling which can lead to a risk of explosion, especially in updraft gasifiers [31] [32].

8.4. Fixed Carbon

The value of the fixed carbon is calculated as follows [32]:

FC = 100 – (%moisture + %volatile matter + %ash)

9. ULTIMATE ANALYSIS

Biomass fuels are characterized using the ultimate and proximate analysis. The ultimate analysis gives the composition of the biomass in weight percentage of carbon, hydrogen and oxygen as well as sulfur and nitrogen. This analysis will show the elemental composition differences between sawdust and other biomass fuels. The composition variations among biomass fuels are large, but as a class biomass has substantially more oxygen and less carbon than other fuels. Less obviously, nitrogen, chlorine, and ash vary significantly among biomass fuels. Generally, biomass has relatively low sulfur compared to other fuels [33].

1. Calculation of the percent fixed carbon on a dry, mineral-matter-free basis:

$$DMMFFC = \frac{FC}{FC+VOL} \times 100$$

DMMFFC = dry mineral matter free fixed carbon
FC = fixed carbon from fuel analysis
VOL = volatile matter

2. Calculation of the percentage volatile matter on dry, mineral-matter basis

$$DMMFVOL = \frac{VOL}{FC+VOL} \times 100$$

DMMFVOL = dry mineral matter free volatile matter
FC = fixed carbon from fuel analysis
VOL = volatile matter

3. Calculation of the weight percent of carbon in the fuel.

$$C = \frac{DMMFFC + 0.9(DMMFVOL - 14) \times (VOL+FC)}{100}$$

C = elemental carbon in the fuel
DMMFFC = dry mineral matter free fixed carbon
DMMFVOL = dry mineral matter free volatile matter
FC = fixed carbon from fuel analysis

4. Calculation of the weight percent of nitrogen in the fuel.

$$N_2 = \frac{(2.1 - 0.012 \times DMMFVOL) \times (VOL+FC)}{100}$$

N_2 = Nitrogen in the fuel.
C = elemental carbon in the fuel.
DMMFVOL = dry mineral matter free volatile matter.
FC = fixed carbon from fuel analysis.

5. Calculation of the weight percent of hydrogen in the fuel.

$$H_2 = \frac{DMMFVOL \times 7.35}{DMMFVOL + 10} - 0.013 \times (VOL + 8)$$

H2 = Hydrogen in the fuel.
DMMFVOL = dry mineral matter free volatile matter.
FC = fixed carbon from fuel analysis.
VOL = volatile matter.

6. Calculation of the weight percent of oxygen in the fuel.

$$O_2 = 100 - (Ash + H_2 + C + MOISTURE + N_2)$$

O2 = Elemental oxygen in the fuel.
Ash = ash analysis from the fuel.
H2 = Elemental hydrogen in the fuel.
C = Elemental carbon in the fuel.

7. Higher calorific value (HCV);

$$HCV = \frac{1}{100}(35000C + 143000(H - \frac{O}{8})$$

H = Hydrogen in the fuel (%).
C = Carbon content in the fuel (%).
O = Oxygen in the fuel (%).

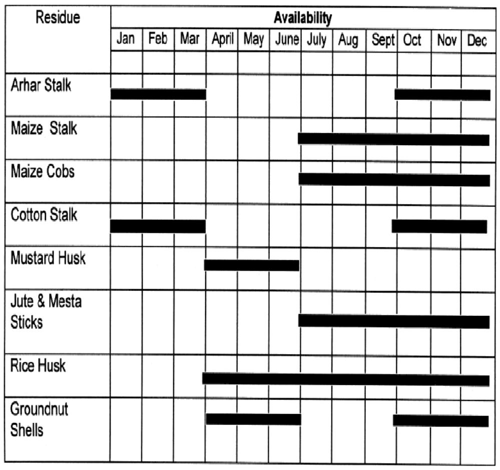
8. Lower calorific value(LCV);

$$LCV = HCV - \frac{9}{100} \times H \times 2442$$

HCV = Higher calorific value in KJ/Kg
H = hydrogen in the fuel [34] [35] [36]

10. BIOMASS AVAILABILITY

Agricultural waste may be used in several applications; they are used as a fuels for cooking, water and process heating, foods for animals, feed stocks for fertilizer for agricultural field, materials for roof construction, direct burning in boilers. All the non-fodder, non-fertilizer agricultural residues with low moisture content it will be considered as feedstock's for biomass gasification process. Biomass is not available throughout the year, and the amounts available depend upon harvesting time, storage related characteristics, the storage facility. It has been observed that, except for cotton pod, it considered in the present work are available for a maximum period of 6 months. The broad periods of availability of some important agricultural residues are presented in Table[37].



11. COLLECTION COST

The biomass is required to be collected at a single point in a farm/agro-industry for stacking before transportation. The collection cost of agricultural residues depends upon the agricultural wage rate and time required for their collection in a particular area. The collection cost, Crc can be determined by dividing the daily wage rate. W, by the carrying capacity, Cc (tones per trip) and the number of trips, n, made by a person in a day[38].

$$Crc = W / (Cc \times n)$$

12. CONCLUSION

Renewable biomass has also been considered as potential feed stocks for gasification to produce the producer gas. They gasification of biomass is the thermal treatment which result in a high proportion of gaseous products and small quantities of char and ash. Different process parameters should be consider for the gasification process for proper production of gas. This proximate and ultimate analysis of material will helpful for producing good quality and quantity of producer gas.

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