International Journal of Research Studies in Biosciences (IJRSB)
August 2015, PP 35-37
ISSN 2349-0357 (Print) & ISSN 2349-0365 (Online)
www.arcjournals.org

Gasification of Agricultural Residues

Rewa Kulshrestha[1], Yashwant Kumar[2], Soumitra Tiwari[3]

[1-3]Department of Food Processing and Technology
Bilaspur University, Bilaspur, Chhattisgarh, India.

Abstract: *Gasification is a flexible, commercially proven and efficient technology. In gasification process, wood, charcoal and other biomass materials are gasified to generate so called ´producer gas´ for power or electricity generation. Theoretically, almost all kinds of biomass with moisture content of 5-30 % can be gasified; however, not every biomass fuel leads to the successful gasification. The biggest advantage of utilising agricultural residues is that it does not compete with the production of food, and if it can become a by-product that can be utilised economically for the production of energy, it will result in lower food prices.*

Keywords: *Gasification, producer gas, and agricultural residues.*

1. Introduction

Gasification is a partial oxidation process whereby a carbon source such as coal, natural gas or biomass, is broken down into carbon monoxide (CO) and hydrogen (H_2), plus carbon dioxide (CO_2) and possibly hydrocarbon molecules such as methane (CH_4). The end products of gasification include solids, ash and slag, liquids and synthesis gas, or syngas. The gas has a calorific value, or potential heat content, equivalent to 25% that of natural gas if ambient air is used or 40% if oxygen-enriched air is used. The resultant gas can be used for fuelling a compression ignition engine in dual fuel mode or a spark-ignition (SI) engine in gas alone mode. Harnessing of energy from biomass via gasification route is not only proving to be economical but also environmentally benign [Mukunda et al, 1993]. Though there has been a sporadic interest in biomass gasifiers whenever there has been an oil crisis, sustained global interest developed only in the recent times for reasons like Green House Gas (GHG) emission reduction and carbon-trading through clean development mechanisms (Rao 2003). History and development of gasification technology is highlighted in Table 1.

Table 1. *Key chronicle in gasification technology*

1788	Robert Gardner obtained the first patent with regard to gasification
1840	First commercially used gasifier was built in France
1861	Introduction of Siemens gasifier: first successful unit
1939-1945	Extensively used for transportation and on farm systems
After 1945	After end of second world war, with plentiful gasoline and diesel available at cheap cost, gasification technology lost glory and importance
1950- 1970	Gasification was " Forgotten Technology "
After 1970	Renewed interest in the technology for power generation at small scale

Gasification process chemically & physically changes biomass through the addition of heat. It instead of directly burning the fuel to generate heat—convert biomass into a low-Btu to medium-Btu content combustible gas, which is a mixture of carbon monoxide, hydrogen, water vapor, carbon dioxide, tar vapor, and ash particles. The complete gasification system consists of gasification unit (gasifier), purification unit and energy converter - burners or internal combustion engine. The producer gas obtained is used in internal combustion engine for power or electricity generation. The major drawback of gasification technology is complex equipment (gasifier) and high maintenance cost. The presence of tar (high molecular weight hydrocarbons) in the syngas produced from biomass is also one of the biggest technical challenges for large-scale biomass gasification plants.

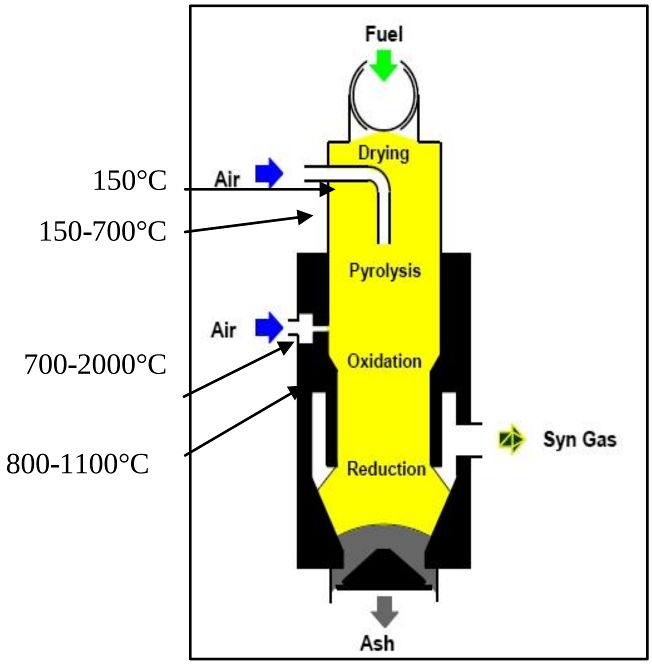
Table 2. *Stages of gasification process*

Drying: Biomass fuels consist of moisture ranging from 5 to 35 %. At the temperature above 100°C, the water is removed and converted into steam. In the drying, fuels do not experience any kind of decomposition.

Pyrolysis: Pyrolysis is the thermal decomposition of biomass fuels in the absence of oxygen.

Oxidation: Air is introduced.

Reduction: In reduction zone, a number of high temperature chemical reactions take place in the absence of oxygen.



2. Types of Gasifiers

In small-scale gasifiers, the reactions take place in a stationary or fixed 'bed' of biomass. In an updraft gasifier, biomass is loaded at the top of the gasifier and air is blown in at the bottom. This type of gasifier produces gas that is contaminated by tar and is therefore too dirty to be used in an internal combustion engine. In a downdraft gasifier, air is drawn downwards through the biomass. The main reactions occur in a constriction or 'throat', where the tars and volatile gases break down into carbon monoxide and hydrogen at a much higher temperature than in an updraft gasifier. The throat is usually made from ceramic to withstand this temperature. Downdraft gasifiers produce cleaner gas.

The power output from fixed bed gasification/engine systems ranges from about 10 kW to 1,000 kW (electrical). Systems such as fluidised beds, two-stage processes and plasma technologies have been used for larger-scale biomass gasification.

3. Why Agricultural Residues?

Agricultural residues are basically biomass materials that are by product of agriculture. It includes cotton stalks, wheat and rice straw, coconut shells, maize and jowar cobs, jute sticks, rice husks, pigeon pea stalks etc. Many developing countries have a wide variety of agricultural residues in ample quantities. Agricultural residues which are considered waste can be converted into high energy through biomass gasification. Other benefits of biomass gasification include: reduced need for landfill space for disposal of solid wastes, decreased methane emissions from landfills, & reduced risk of groundwater contamination from landfills. Theoretically, almost all kinds of biomass with moisture content of 5-30 % can be gasified; however, not every biomass fuel leads to the successful gasification. Coconut shells and maize cobs have been successfully tested for fixed bed gasifiers and they unlikely creates any problems. Most cereal straws contain ash content above 10 % and present slagging problem in downdraft gasifier. Rice husk with ash contents above 20 % is difficult to gasify.

Wheat straw Rice straw Cotton stalks

Fig 1. *Different agricultural residues*

4. Conclusion

The key to a successful design of gasifier is to understand the properties and thermal behvaiour of the fuel as fed to the gasifier. Operation of gasification system demands knowledgeable and skilled operator. The biomass gasification technology is theoretically an interesting option for rural development. It promises sustainable conversion of locally available biomass into energy. Gasification of agricultural residue to produce clean syngas is though expensive, but has the highest energy conversion efficiency between 28 and 36 %. Community participation can reduce the expensive installation and building cost.

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