Significance of Biomass in Reduction of Global Warming

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ABSTRACT

Our over dependency on fossil fuel creates so many environment problems. Ozone layer depletion and global warming is the major environmental problem due to excess use of non renewable energy. In present scenario pressures on the global environment have led to use of renewable sources of energy. Renewable energy is also clean energy, which would mean its usage would not be damaging to the quality of the environment. Biomass is one potential source of renewable energy. Biomass is a sustainable fuel that can deliver a significant reduction in net carbon emissions when compared with fossil fuels. There are many biomass conversion technologies into useful energy include anaerobic digestion, Pyrolysis, gasification, Trans-esterification, fermentation and combustion. The gasification of biomass is a thermo-chemical process by which solid fuel can be converted into gaseous fuel. The gaseous products can be burned to generate heat or electricity. In present paper we will discuss the method of electricity generation from agricultural waste and significance of this technology in respect of decrease in CO_2 emission.

Keywords: Biomass, Gasification, Global warming, CO_2 emission, Fossil fuels.

I INTRODUCTION

Biomass is any organic matter that can be used as energy source. The term biomass encompasses a large variety of materials, including wood from various sources, agricultural residues, and animal and human waste. Biomass is biological material derived from living, or recently living organisms, such as wood, waste, hydrogen gas, and alcohol fuels [5]. Biomass gets its energy through photosynthesis. With sunlight, water and oxygen plants make carbohydrates, which is good source of energy. Biomass is renewable source of energy because we can grow more plants in short time. Biomass is used for facility heating, electric power generation, and combined heat and power. According to Annual report of World Bank (2010) India is the second-largest contributor to the increase in global energy demand to 2035. In the next 25 years, India's electricity demand is expected to grow at an average annual rate of 7.4 percent .The use of biomass to provide energy has been fundamental to the development of civilization. The availability of biomass in India is estimated at about 500 million tons per year including residues from agriculture, agricultural industries, and forest products. A survey by the Ministry of New and Renewable Energy indicated that 15-20 percent of total agricultural wastes could be used for power generation, without altering their present uses. This implies availability of 120 to 150 million tons of surplus agro-industrial and agricultural residues per year that could be made available for power generation. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalks, coconut shells, soy husk, oilseed cakes, coffee waste, jute wastes, peanut shells, and sawdust [1].

Biomass is one potential source of renewable energy and the conversion of plant material into a suitable form of energy, usually electricity or as a fuel for an internal combustion engine can be achieved using a number of different conversion routes [7]. Biomass energy conversion technologies include anaerobic digestion, pyrolysis, gasification, trans-esterification, fermentation and combustion [6]. Gasification produces a synthesis gas with usable energy content by heating the biomass with less oxygen than needed for complete combustion. Pyrolysis yields bio-oil by rapidly heating the biomass in the absence of oxygen. Anaerobic digestion produces a renewable natural gas when organic matter is decomposed by bacteria in the absence of oxygen [2].Gasification as well as anaerobic digestion processes seems to be most attractive in Indian scenario [10]. The average gas composition was found to be 21.6% CO, 36.08% H, 14.49% CO2, 1.4% CH_4 and 26.46% N_2. These gases do, however, not present similar energy significance, because some of them are combustible, whilst some (CO_2 and N_2) are waste gases. Combustible gases are CH_4, H_2 and CO_2[8]. Gasification is the thermo-chemical conversion of Solid Carbonaceous fuel into combustible gas (main by CO & H_2) by partial combustion i.e. combustion in the presence of limited air. The mixture of combustible gases thus produced is termed “Producer Gas”. It is also called as Low Btu Gas or Low Calorie Gas, because of its low energy content. This gas is good enough for use in S.I. Engine or C.I.Engine. Since it is a low calorie gas. It not possible to run C.I. Engine on 100% gas. A pilot jet is necessary for ignition. However an S.I. Engine can run on 100% gas because of presence of an ignition source namely sparkplug.

II EXPERIMENTAL

(a) Availability of agricultural waste: The availability of biomass in India is estimated at about 500 million tons per year including residues from agriculture, agricultural industries, and forest products. A survey by the Ministry of New and Renewable Energy indicated that 15-20 percent of total crop residues could be used for power generation, without altering their present uses. This implies availability of 120 to 150 million tons of surplus agro-industrial and agricultural residues per year that could be made available for power generation. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalks, coconut shells, soy husk, oilseed cakes, coffee waste, jute wastes, peanut shells, and sawdust (MNRE).There is a large variability in agricultural wastes generation and their use depending on the cropping intensity, productivity and crops grown in different states of India. Residue generation is highest in Uttar Pradesh (60 Mt) followed by Punjab (51 Mt) and Maharashtra (46 Mt).

(b) Collection of agricultural waste from farmers field: The agricultural wastes are normally collected manually and transported to farm yard. The tractor operated bailers are used for mechanized collections. The available bailers can collect biomass in the form of densified bails of 800 to 900 kg in one hour. The biomass assessment was made and found that 100 kW power plants would require 400 tonnes of agricultural waste and with 20% collection efficiency 3.2 km radius catchment area is required on single crop basis. The cost of biomass collection is about Rs 400 per tonne. The cost of transportation is also Rs 300-400 per tonne for lead distance 10 km.

Fig.1 Manual collection of biomass

Fig.2 Transportation of biomass

(c) Densification of agricultural wastes: A major disadvantage of agricultural residues as a fuel is their low bulk density, which makes handling difficult, transport and storage expensive, and gives rise to poor combustion properties. However, these problems can be overcome by compacting the loose biomass to form briquettes. The opportunity to utilise more efficiently agricultural residues, with a reduction in pollution levels, has in recent years aroused the interest of developing countries, as well as some industrialised ones, in briquetting. Briquetting is a relatively new technology for developing countries [4].There are different types of briquetting plants available for densification of biomass.

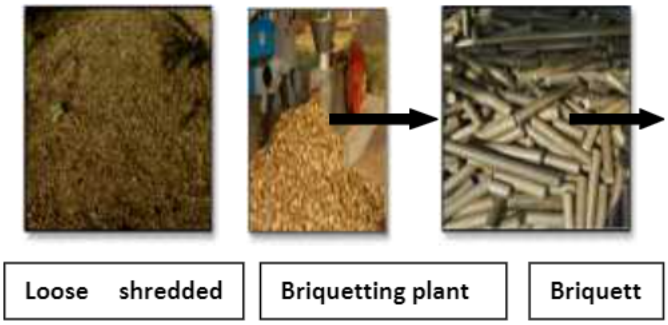


Fig.3 Showing densification of loose biomass

(d) Gasification: Gasification is a thermochemical conversion of biomass which takes place in limited supply of oxygen in close container called gasifier. Gasification occurs by heating biomass to high temperature (1200 – 1400°C) in an oxygen deprived environment, therefore limiting combustion. The process takes place in four stages: drying, pyrolysis, gasification (oxidation) and finally combustion. The first phase of heating and drying is unproductive in terms of energy output, as energy is used to evaporate remaining moisture from the biomass. In the pyrolysis phase volatile components of the biomass are removed. The temperature range in this stage is 450 – 600°C. Pyrolysis vapour is comprised of water, carbon monoxide, hydrogen, methane, volatile tars and carbon dioxide. The remaining biomass is a carbonized solid fuel – charcoal, with 10 - 25 % of the original fuel mass. The final stage at temperatures between 700°C - 1200°C involves the conversion of char into producer gas that constitutes about 16% CO, 20% H_2, 50% N_2, 12% CO_2 and 2% CH_4 and products such as ash and powder slag . Different zones of gasifier according to temperature is described below:

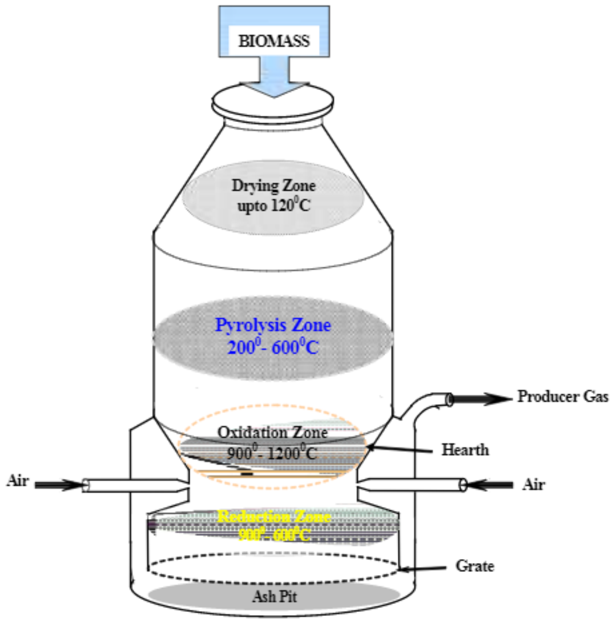


Fig. 4 Schematic diagram of downdraft gasifier showing different zones

(i) **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.

(ii) **Pyrolysis:** Pyrolysis is thermal decomposition of biomass fuels in the absence of oxygen. Pyrolysis involves release of three kinds of products: solid, liquid and gases. The ratio of products is influenced by the chemical composition of biomass fuels and the operating conditions. The heating value of gas produced during the pyrolysis process is low (3.5 - 8.9 MJ/m^3).

(iii) **Oxidation:** Introduced air in the oxidation zone contains, besides oxygen and water vapours, inert gases such as nitrogen and argon. These inert gases are considered to be non-reactive with fuel constituents. The oxidation takes place at the temperature of 700-2000 ° C. Heterogeneous reaction takes place between oxygen in the air and solid carbonized fuel, producing carbon monoxide. Plus and minus sign indicate the release and supply of heat energy during the process respectively.

$C + O_2 = CO_2 + 406$ [MJ/kmol]
$H_2 + ½ O_2 = H_2O + 242$ [MJ/kmol]

(iv) **Reduction:** In reduction zone, a number of high temperature chemical reactions take place in the absence of oxygen. The principal reactions that take place in reduction are mentioned below.

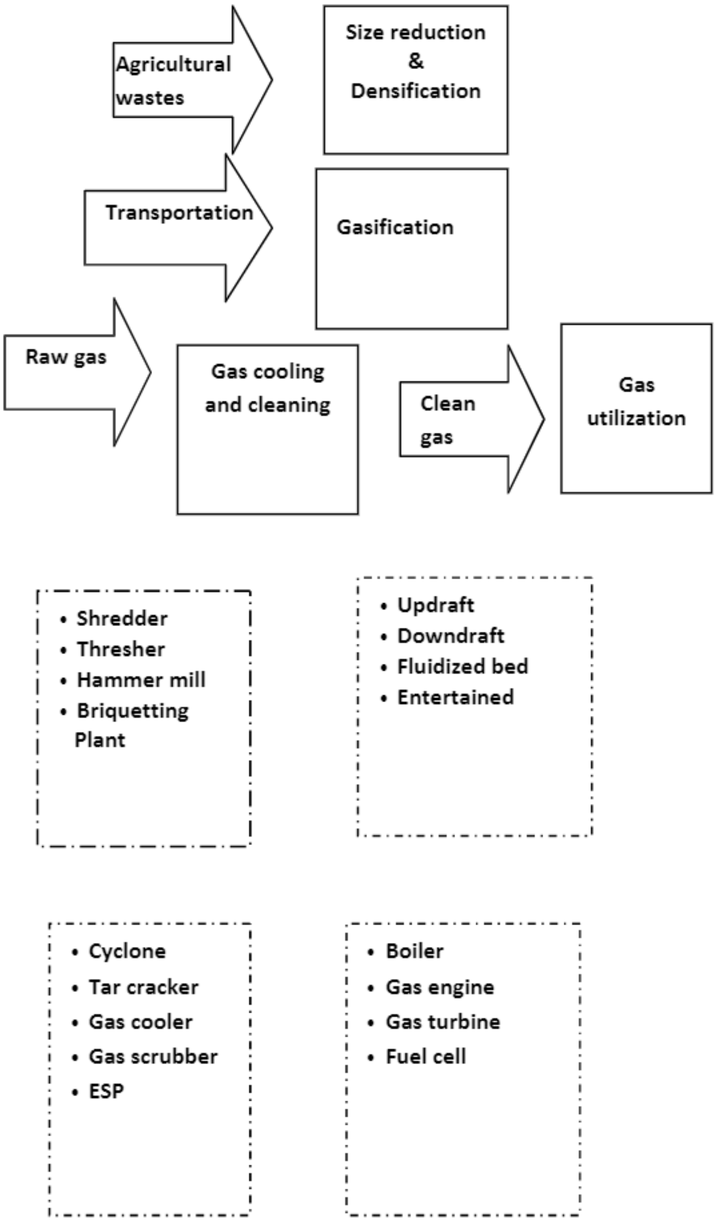
1. $CO_2 + C = 2CO - 172.6$ [MJ/kmol] ------------------- - Boudouard reaction
2. $C + H_2O = CO + H_2 - 131.4$ [MJ/kmol] ------------- ---- Water-gas reaction
3. $CO_2 + H_2 = CO + H_2O + 41.2$ [MJ/kmol] ----------- ------ Water shift reaction
4. $C + 2H_2 = CH_4 + 75$ [MJ/kmol] --------------- ------- ------ Methane production reaction

Main reactions show that heat is required during the reduction process. Hence, the temperature of gas goes down during this stage. If complete gasification takes place, all the carbon is burned or reduced to carbon monoxide, a combustible gas and some other mineral matter is vaporized. The remains are ash and some char (unburned carbon)

III COOLING AND CLEANING OF GAS

The temperature of gas coming out of generator is generally in between 300^0C -500 ^{0}C. This gas has to be cooled in order to raise its energy density. Various types of cooling equipment have been used to achieve this end. Most coolers are gas to air heat exchangers where the cooling is done by free convection of air on the outside surface of heat exchanger. Since the gas also contains moisture and tar, some heat exchangers provide partial scrubbing of gas. Thus ideally the gas going to an internal combustion engine should be cooled to nearly ambient temperature.

Cleaning of the gas is trickier and is very critical. Normally three types of filters are used in this process. They are classified as dry, moist and wet. In the dry category are cyclone filters. They are designed according to the rate of gas production and its dust content. The cyclone filters are useful for particle size of 5 µm and greater 26. Since 60-65% of the producer gas contains particles above 60 µm in size the cyclone filter is an excellent cleaning device. After passing through cyclone filter still the gas contains fine dust, particles and tar. It is further cleaned by passing through either a wet scrubber or dry cloth filter. In the wet scrubber the gas is washed by water in counter current mode. The scrubber also acts like a cooler, from where the gas goes to cloth or cork filter for final cleaning.[9]



IV ENVIRONMENTAL & SOCIAL BENEFITS

i. Biomass is renewable source of energy. Electricity produced by biomass reduces the threat of global climate change. The environment could also be saved by avoiding the burning of these residues in the field. It has been estimated that 20 kW power plant could replace 125 t CO_2 per year as compared to electricity generating unit through grid.

ii. The raw material which is being burnt in the field could be used & farmers may get benefit by selling these residues to the power plant. This will support the rural upliftment by providing assured electricity supply along with additional income generation to rural mass.

iii. 20 kW power plant could generate employment opportunity of about 600-700 man-days for various activities of power plant. The system also reduces environmental degradation caused by petrochemicals. At the firm level, less pollution would be released into the environment. This small power plant could generate employment opportunity of about 600-700 man-days for various activities of power plant.

V CONCLUSION

Biomass based power plant is an alternative source of electricity generation. This source decreases the dependency of human being on non-renewable sources of energy, resulting in the decrease in pollution level as well as global warming. 20 kW power plants could replace 125 t CO_2 per year as compared to grid electricity which is the main source of global warming. Different stages of electricity generation from biomass through power plant generate employment as well.

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