THERMOCHEMICAL STUDY OF BIOMASS ENERGY

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ABSTRACT

Rural population of India depends on biomass energy for cooking, space heating and water heating. Though most of the energy needs in India is comes from fossil fuels, 70% of the rural population depends on the biomass-energy for their domestic usage in the country. About 65% of the Indian population lives in rural area where 70% of the primary energy need is supplied by bio-energy resources. Also, about 24% of the urban households depend on firewood, 20% on kerosene and 46% on LPG for cooking in India. Biomass energy resources are renewable energy and combustion would not produce poisonous gases and ash with sufficient oxygen supply. A village level study on the present scenario of domestic energy consumption will help to assess the demand and supply of bio-energy in the country. India is chosen for biomass energy assessment which has evergreen as well as moist and dry deciduous forest, where the majority of the people live in rural area or in semi urban area, mostly dependent on forest, agricultural and animal residues for domestic energy need. Biomass resources availability is computed based on the compilation of data on the area and productivity of agriculture, forests and horticulture crops. Sector-wise energy demand is computed based on the National Sample Survey Organization (NSSO study) data, primary survey data and from the literature. The ratio of biomass resource availability to demand gives the biomass resource status. The ratio greater than one indicates biomass resource surplus zones, while a ratio less than one indicates scarcity. The supply/demand ratio in the district ranges from less than 0.5 to more than 2. If the ratio is less than 1 (demand more than supply) then that is fuel wood deficit place and where the ratio is more than 1 (supply more than demand) then it is referred to as fuel wood surplus region.

Keyword: - *biomass, biomass energy technologies, agricultural and horticultural residues, biomass gasifier, pyrolysis.*

1. INTRODUCTION

1.1 Biomass

Biomass is an organic matter that has stored energy produced by the process of photosynthesis. The chemical materials (organic compounds of carbons) are stored in biomass. This stored chemical energy is used to generate energy. It exists in one form as plants and transferred through the food chain to animal's bodies and their wastes. The most common biomass used for energy is wood from trees. In India wood has been used by humans for producing energy for heating and cooking for a very long time. Many of the biomass fuels used today come in the form of wood products, dried vegetation, crop residues, and aquatic plants. Biomass has become one of the most commonly used renewable sources of energy in the last two decades, in the generation of electricity. It is such a widely utilized source of energy, probably due to its low cost and indigenous nature, that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, mostly for cooking and heating.

1.2 Conversion process

Biomass has been converted by partial-pyrolisis to charcoal. Charcoal, in turn has been used for forging metals in industries and cooking. Both wood and charcoal formed part of the backbone of the early Industrial Revolution prior to the discovery of coal for energy. Wood is still used extensively for energy in both household situations, and in industry, particularly in the timber, paper and pulp and other forestry-related industries. Woody biomass accounts for over 20% of the primary energy consumed in India, and it accounts for much more of the primary energy consumed in most of the developing world, primarily for cooking and space heating. It is used to raise steam, which, in turn, is used as a by-product to generate electricity. Considerable research and development work on biomass is currently underway to develop smaller gasifiers that would produce electricity on a small-scale as well as produces gaseous fuel.

2. TYPES OF BIOMASS

There are many ways to classify the biomass. Generally, it can be divided into two main category: primary biomass and secondary or waste biomass. Table 1 shows a detailed classification of biomass:

Table-1: Types of biomass

Primary Biomass	**Secondary Biomass**
Woody biomass	Agricultural waste
Herbaceous biomass	Municipal waste
Energy crops	Industrial waste

2.1 Primary biomass

Primary biomass comes from plants directly. Woody biomass includes trees, vines, shrubs and bushes. Herbaceous biomasses are the plants that die annually at the end of the growing season. Energy crops are those plants exclusively for producing energy. These corps have high energy density and short growth period.

2.2 Secondary biomass

Waste biomass or secondary biomass is the biomass derived from virgin biomass during the different stages of its production or come from the industrial and municipal wastes. Agricultural wastes mainly include straw, sugar beet leaves and animal manure. Forestry wastes contain bark, wood blocks and leaves etc.

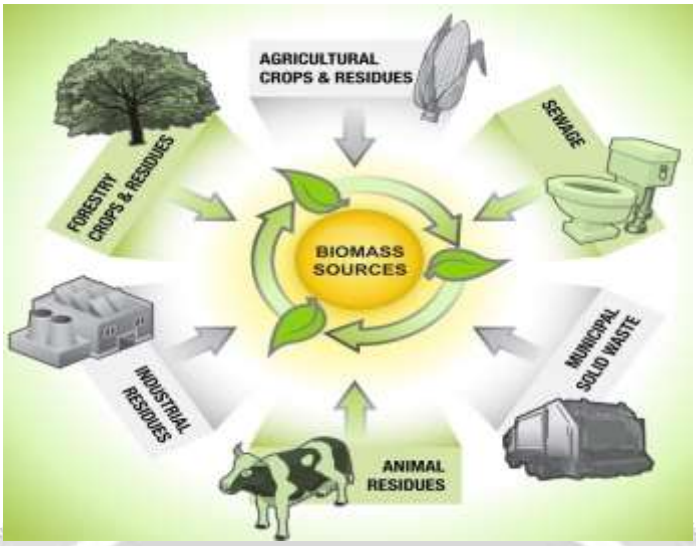

Fig-2 Sources of Biomass

2.3 Composition of biomass

Biomass is constituted by a variety of complex organic compounds, moisture , and a few inert solids called ash . The organic compounds consists carbon, hydrogen, oxygen, nitrogen, and small amount of chlorine and sulfur.

Carbon + hydrogen + oxygen + nitrogen + sulfur + chlorine + moisture + ash = 100%

3. OBJECTIVE

The primary objective of the study is to assess the biomass energy status in India across the agro climatic zones. This includes:

1. Identifying the chemical behavior of biomass in gasifier.
2. Techno-economic analysis of biomass energy applications.
3. The role of biomass energy in sustainable development.

4. GASIFICATION

Gasification is the process of converting the carbonaceous solids into synthesis gas under certain range of temperatures and oxygen-starved conditions. A typical gasification process includes drying and pyrolysis, combustion and char gasification.

4.1 Gasification process

Biomass is first preheated in order to dry the biomass for the further use by evaporating of moisture. It then undergoes thermal decomposition or pyrolysis in the absence of oxygen. In the pyrolysis part, the biomass breaks down into volatiles, liquids including tar and heavy hydrocarbons, and carbonaceous solid known as char. Gasification then occurs in the presence of a gasifying medium. The gasifying medium can be oxygen, air, or steam. During the gasification part, both the gas-solid reactions and the gas-phase reactions happen.

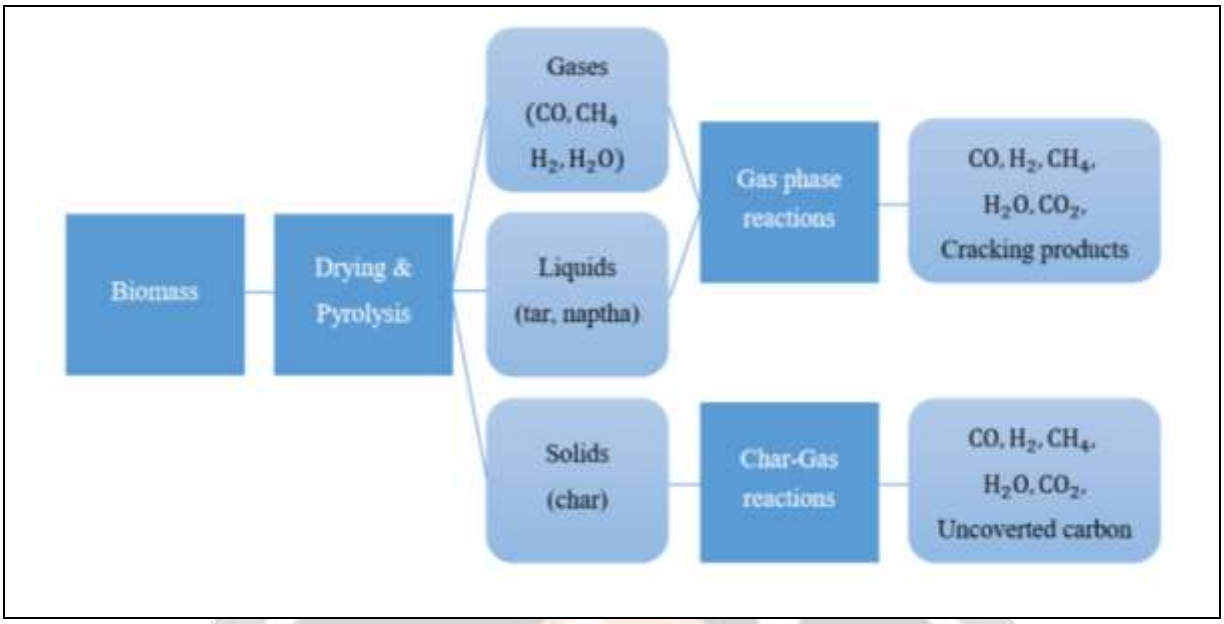

Fig -3: Gasification process

4.2 Chemical reactions

The main chemical reactions takes place in gasifier are summarized as follows:

Biomass pyrolysis:

Biomass ⟶ char+ tar+ H_2O + light gas ($CO+CO_2+H_2+CH_4+N_2$) …. (Endothermic)

Heterogeneous reactions:

Char combustion reactions

Partial combustion: $C + 1/2O_2$ ⟶ CO (-111kJ/mol)

Complete combustion: $C + O_2$ ⟶ CO_2 (-394kJ/mol)

Char gasification reactions

Boudouard reaction: $C + CO_2$ ⟶ 2CO (+173kJ/mol)

Steam gasification: $C + H_2O$ ⟶ CO + H2 (+131kJ/mol)

Hydrogen gasification (Methanisation): $C + 2H_2$ ⟶ CH4 (-75kJ/mol)

Homogeneous gas phase reactions:

Carbon monoxide oxidation: $CO + 1/2O_2$ ⟶ CO_2 (-283kJ/mol)

Hydrogen oxidation: $H_2 + 1/2O_2$ ⟶ H_2O (-242kJ/mol)

Methane oxidation: $CH_4 + 2O_2$ ⟶ $CO_2 + 2H_2O$ (-283kJ/mol)

Water gas shift reaction: $CO + H_2O$ ⟶ $CO_2 + H_2$ (-41kJ/mol)

5. CONCLUSIONS

1. Biomass energy has the potential to meet the household energy demand through decentralized electricity generation and adoption of improved energy source in India. The supply/demand ratio of biomass resources in the country ranges from less than 0.5 (Bioresource deficit) to more than 2.
2. The chemical reactions involved are endothermic as well as exothermic so there will be need of some initial heat energy to start reactions.
3. The chemical reactions depend on the temperature, so there will be need of thermal analysis of biomass gasification process.

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