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Production of Biogas and Biochar by Pyrolysis

Rajesh¹, Pratheeban¹, Naveen¹, Velmurugan²

U.G. Student, Department of Mechanical Engineering, Francis Xavier Engineering College, Vanarpettai, Tirunelveli,
Tamil Nadu, India¹

Associate Professor, Department of Mechanical Engineering, Francis Xavier Engineering College, Vanarpettai,
Tirunelveli, Tamil Nadu, India²

ABSTRACT: Growing uncertainty about our more traditional energy sources is increasing demand for sustainable energy. Given the world population, the increasing energy consumption and the global warming situation is likely increasing day by day, the necessity for long-term alternative energy source is needed. In a world in which the uncertainty surrounding traditional energy sources seems greater than ever, Biomass is a promising eco-friendly alternative renewable energy at the same time, biogas production is helping to minimize quite significant emission of surplus nutrient substances into the aquatic environment. In this project we use the pyrolysis process to produce the biogas and biochar.

KEYWORDS: Biogas, Biochar, Pyrolysis process, waste into usable energy.

I. INTRODUCTION

Biomass is a promising eco-friendly alternative source of renewable energy in the context of current scenarios. Biomass resources are found almost everywhere and can become reliable and renewable local energy source to replace fossil fuels. Although complex in nature, biomass contain small amount of Sulphur, nitrogen and ash. Biomass to energy is a sustainable solution that can reduce greenhouse-gas emission by substituting fossil fuels such as oil, gas, or coal with biomass and also reducing a potential agricultural waste disposal problem. It is important to distinguish between “traditional” and “modern” use of biomass. Traditional use of biomass such as dung, charcoal and firewood for cooking and heating and modern use of biomass is used on large scale for heating, power generation, biofuel and biogas production. Biomass resources are traditionally dispersed by nature and occur in numerous relatively small, local sources. With the exception of municipal and industrial wastes, these resources tend to be available in rural areas. Biomass energy originates from forests, agriculture or organic waste streams.

There are great many ways to classify biomass types. Biomass feedstock can be classified according to

- Physical and chemical properties (moisture content, calorific value, etc)
- Source (energy crop, waste product)
- Sector of origin (agriculture, industry, waste processing sector)
- Potential energy application (electricity, heat, transport fuel)
- Legal status (waste or product)

Biomass can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electrical energy, heat, chemicals or fuels. Biomass conversion technologies converted biofuels into a form usable for energy generation. Usually a distinction is made between a primary and secondary bioenergy conversion processes and likewise between primary and secondary biomass resources. Primary (unprocessed) biofuels are those where the organic material is used essentially in its natural form (as harvested). Such fuels are directly combusted, usually to supply cooking, space heating or electrical production needs, although there are small and large-scale industrial application for steam raising and other processes requiring low-to-medium temperature heat.

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Secondary (processed) biofuels in the form of solids (e.g. charcoal), liquids (e.g. alcohol, vegetable oil), or gases (e.g. biogas) can be used for a wider range of applications with higher efficiency rates on average, including transport and high-temperature industrial processes. The aim of processing biofuel (fuel produced directly or indirectly from biomass) is to provide fuels with clearly defined fuel characteristics and ensure a technically simple and environmentally sound conversion into useful energy.

II. RELATED WORK

2. CONVERSION PROCESSES:

The conversion of biomass into biofuels in various ways are

- 1) Thermo-chemical processes
 - a) Pyrolysis
 - b) Gasification
 - c) Carbonization
 - d) Liquefaction
 - e) Combustion
- 2) Bio-chemical processes
 - a) Anaerobic digestion
 - b) Ethanol fermentation
- 3) Chemical processes
 - a) Esterification

In this project the pyrolysis process is used to convert the biomass into the biofuel.

2.1 PYROLYSIS:

Pyrolysis is the thermal decomposition of materials at elevated temperatures in an inert atmosphere. It involves the change of chemical composition and is irreversible. The word is coined from the Greek-derived elements pyro “fire” lysis “separating”. Pyrolysis is most commonly used in the treatment of organic materials. It is one of the processes involved in charring wood. Pyrolysis of organic substances produces volatile products and leaves a solid residue enriched in carbon char. Extreme pyrolysis, which leaves mostly carbon as the residue is called carbonization. The process is used heavily in the chemical industry, for example to produce ethylene, many forms of carbons, and other chemicals from petroleum, coal and even wood, to produce coke from coal. It can also be used for thermal cleaning, and industrial application to remove organic substances such as polymers, plastics and coating from parts. Aspirational applications of pyrolysis would convert waste plastics back into usable oil, waste into safely disposable substances, biomass into biogas and biochar

2.2 BASIC PRINCIPLE OF PYROLYSIS:

The thermal decomposition of process of pyrolysis using biomass takes place in the absence of oxygen under inert atmosphere. The fundamental chemical reaction is very complex and consists of several steps. The end product of biomass pyrolysis consist of biochar, gases. Pyrolysis process emits mainly methane, hydrogen, carbon monoxide and carbon dioxide. The organic materials present in the biomass substrate starts to decompose around 350°C and it can proceed until 600°C with the presence of oxygen. Biomass is mainly composed of long polymeric chain of cellulose, lignin, hemicellulose, pectin and others. The larger molecules of organic materials start to decompose to yield smaller molecules, which are released from the process stream as gases, condensable vapours and solid char during pyrolysis process. The proportion of each end product depends on temperature, time and heating rate.

Woody biomass was initially used to produce charcoal. The charcoal based on wood during heating produces negligible amount of smoke. Earlier it was extensively used for melting ore to extract iron. However, the process had drawbacks of less yield percentages, less energy and excessive air pollution. After that, modern technology was developed to extract maximum possible energy from biomass using combustion, gasification and pyrolysis. Combustion deals with

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the burning of biomass in presence of oxygen to produce heat. The competence of this practice is not satisfactory. Gasification also takes place under oxygenated atmosphere which will yield gaseous fuels. Nevertheless, pyrolysis is the leading phase for both gasification and combustion processes. Consequently pyrolysis can be considered as part of gasification and combustion.

BIOMASS FEEDSTOCK:

TYPES AND COMPOSITION OF BIOMASS FEEDSTOCK:

The structure of biomass is complex and usually composed of three main natural biomacromolecules: cellulose, hemicellulose and lignin. Besides that it also has extractives and some minerals. The proportion and these basic constituents vary from biomass to biomass. During pyrolysis, cellulose and hemicellulose yield condensable vapours or liquid and gas. Biomass decompose to give gas and solid char. Extractives also produce liquid and gas due to simple volatilization or decomposition. The ash fraction inside the char matrix contains minerals. This distribution of components into products is shown schematically in fig

The vapour produced from initial decomposition of biomass undergoes for secondary reactions to yield soot which also varies due to slow and fast pyrolysis process. Alkali metals act like catalyst by enhancing the char yield. The presence of minerals affects the ignition properties of biochar matrix. It was observed that bio-oil mainly derived from cellulosic substrate around 500°C whereas biochar may be extracted from lignin. whereas biochar may be extracted from lignin. Thus the biomass substrate which contains greater proportion of lignin derivatives can yield more bio-oil yield.

PHYSICHEMICAL PROPERTIES OF BIOMASS:

Based on the process parameters and design of the reactor, presence of moisture can have significant effect on products yield. The charcoal making process proceeds through two distinct steps: drying and pyrolysis steps. During the initial phase of drying, combined water in the pores represented as free water is expelled around 110°C. As much as water is present, it takes more energy to evaporate. After the between temperatures 150 and 200°C combined water present inside the cellulosic chain of wood will be reduced. In the stage of carbonization, water evaporates as white smoke from charcoal kiln.

2.3 PYROLYSIS PRODUCTS:

The products obtained from pyrolysis of biomass are

- 1) Biochar
- 2) Biogas

2.4 BIOCHAR:

Biochar is made from biomass via pyrolysis that may be ploughed into soils in crop fields to enhance their fertility and stability, and for medium -to -long term carbon sequestration in these soils. It has meant a remarkable improvement in tropical soils showing positive effects in increasing soil fertility and in improving disease resistance. Biochar enhances the natural process the biochar captures CO₂, especially through plant production but only a small portion is stably sequestered for relatively long time. The application of biochar to agriculture soil fertility and nitrogen use ratio, selectively immobilize nutrient elements, absorb heavy metals organic contaminants transform Cu²⁺ and Zn²⁺ for plant uptake and change the soil physiochemical properties, including pH, organic carbon. Biochar has received increasing recognition as a soil amendment for sequestering carbon to mitigate climate change. In addition, biochar can affect the fate of pesticides of soil.

2.5 BIOGAS:

Biogas refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is primarily methane (CH₄) and carbon dioxide (CO₂) and may have small amount of hydrogen sulphide (H₂S) and moisture. The gases methane, hydrogen, and carbon monoxide (CO) can be

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combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel, it can be used for any heating purpose, such as cooking. It can also be used in gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, the same way as natural gas is compressed to CNG, and used to power motor vehicles. Sometimes an image may contain text embedded on to it. Detecting and recognizing these characters can be very important, and removing these is important in the context of removing indirect advertisements, and for aesthetic reasons.

III. EXPERIMENTAL

3.1 APPARATUS:



In this apparatus the pyrolyser is connected to the cyclone separator through the connecting pipes. Pyrolyser is placed above the external heater. Then the pyrolyser is fully closed there is no air supply to the pyrolysis reactor. Pyrolyser is closed by air tight sealed cap. Cyclone separator is placed right side of the pyrolyser. There are two pipes are intersect in the cyclone separator. One is inlet pipe and another one is outlet pipe. In inlet pipe the bio gas and moisture particles are coming from the pyrolyser. After the cyclone process only the biogas is passed to the outlet pipe. At the bottom section of cyclone separator the moisture particles and biochar to be collected via pipes. The bottom pipe is controlled by valves.

3.2 OPERATING PROCEDURE:

Initially the biomass dumped into the combustion chamber. In the combustion chamber is heated from outside and the pyrolysis process is performed. In pyrolysis process the biomass is burned without oxygen supply and at the end of the pyrolysis process the biogas is produced from biomass. Then the biogas is send to the cyclone separator and the

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cyclone separator is to separate the char content in the biogas and the biochar is used as a fertilizer for agricultural purpose. And the biogas is used for fuel purpose

IV. EXPERIMENTAL RESULTS

4.1 HIGH HEATING VALUE OF PYROLYSIS BIOCHAR:

Generally, the high heating value of char from the biomass pyrolyzed increases with the treatment temperature. A significant linear correlation there is between the pyrolysis temperature and HHV of the char. The equation to calculate relationships between temperature and the char yield is:

$$\text{HHV} = 0.0069T + 24.68 \text{ [MJ/kg]}$$

For this relation we have used a correlation coefficient equal with 0.9983. The results have proved this linear dependence by the pyrolysis temperature. Thus HHV of char obtained at 450°C is 27.73 MJ/kg, while the HHV for the char resulted from high pyrolysis temperature (800 °C) is higher: 30.15 MJ/kg.

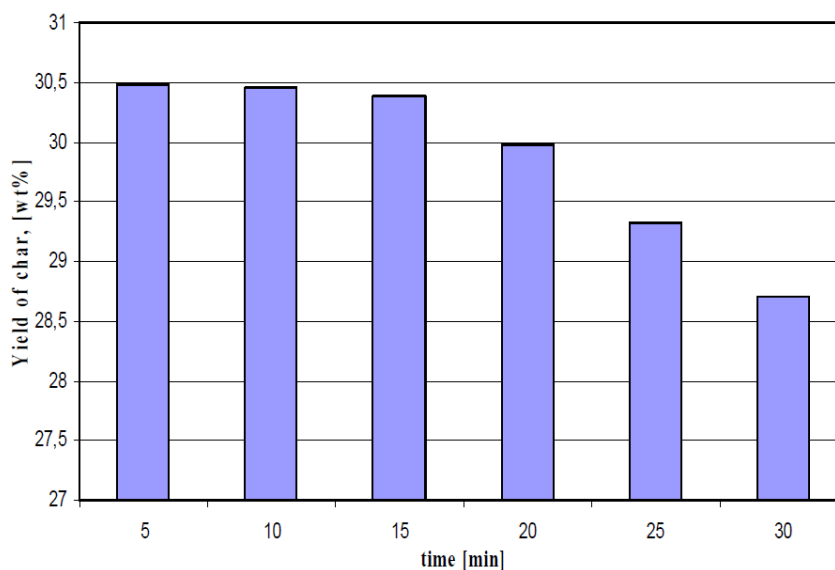
4.2 WATER SEQUESTRATION:

Water holding is a very important property of biochar. The biochar holds 5.6 times its weight in water and always root available. Evaporation is negligible due to long,

$$\begin{aligned} \text{Water holding capacity} &= 5.6 \times \text{the weight of biochar} \\ &= 5.6 \times 0.3 \text{ kg} \\ &= 1.68 \end{aligned}$$

4.3 INFLUENCE OF THE RESIDENCE TIME:

The char yields reflected by the Fig. were produced by pyrolyzing cherry sawdust at temperature equal to 450°C. At this temperature the samples were kept for different residence time: between 5 minutes and 30 minutes. As it can be seen the char yields decrease as the residence time increases. We have obtained the biggest value of char yields in case of the shorter residence time – 30.48% and the smaller value of char for the longer time (30 minute), equal with 28.71%.



The pyrolysis char yields versus residence time

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V. CONCLUSION

Biomass pyrolysis is the processing of agricultural residues, wood wastes and municipal solid waste into clean energy. It is a research challenge to optimize the process by maximizing product quality and quantity while paying proper attention to minimizing costs and environmental concerns

- The use of biomass, as a traditional energy source for the third world, can play a pivotal role in helping the world to reduce the environmental impact of burning fossil fuels to produce energy.
- Biomass is an accepted form of renewable energy and it is seen as a means of helping to reduce global warming, by displacing the use of fossil fuels.
- Such fuels are an alternative to conventional fossil fuels, as well as they offer the possibility of recovering energy from waste deposited in landfills.
- The application of carbonization products may effectively enhance the physiochemical properties of soils and improve the fertility of poor soils.
- From the point of view of agriculture, the application of biochar as a soil conditioner produces numerous benefits, such as the enhancement of the physical, chemical and biological properties of soils, and this contributes to an increased crop yield.

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