Middle-East Journal of Scientific Research 24 (4): 1047-1051, 2016
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2016.24.04.23224

Fabrication and Analysis of Various Biomass Using Slow Pyrolysis Reactor

[1]*M. Balamurugan,* [2]*K. Saravanan,* [2]*D. Ommurugadhasan,* [3]*V. Vasantharaj and* [4]*G. Paramaguru*

[1]P.G Scholar, Mechanical Department, Pondicherry Engineering College, India
[2]Assistant Professor, Mechanical Department, St. Anne's College of Engg and Tech Panruti, India
[3]Assistant Professor, Mechanical Department, CIT college of Engineering. Puducheery, India
[4]Assistant Professor, Mechanical Department, Surya Group of Institution. Vikravandi, India

Abstract: Disposal of commonly used Biomass particals into land fill was becoming more undesirable due to environmental concerns. Therefore, recycling through mechanical and thermo chemical process the various bio mass are converted into useful products. Pyrolysis is a thermal decomposition process that takes place in the absence of oxygen. Slow pyrolysis of BioMass is one of the most emerging technology. A slow pyrolysis reactor was designed and fabricated. It consists of a reactor, heating element and water cooled condenser.. Slow pyrolysis of various biomass was carried out in the pyrolysis reactor to determine the effect of temperature and raw material size on the yield of pyrolysis products. These project concentrates on production and yields of thermo-chemical conversion of biomass into bio-fuels (bio-oil, bio-char and bio-gas).

Key words: Biochar · Bio-oil · Biogas

INTRODUCTION

Renewable energy is of growing importance in satisfying environmental concerns over fossil fuel usage.Wood and other forms of biomass are one of the main renewable energy resources available. Utilizing this energy does not add cabondioxide, which is a greenhouse gas to the atmospheric environment in contrast to fossil. Like other biomass wastes, agricultural wastes contain high amount organic constituents (i.e. cellouse, hemicellouse and lignin) and posse's high energy content. Therefore it can be recognized as a potential source of renewable energy. Due to the lower contents of sulphur and nitrogen in biomass waste, it creates less environmental pollution and health risk than fossil combustion. Some biomass produced in our country is listed.

Pyrolysis: Pyrolysis is the thermal decomposition of organic matter under vacuum of inert atmospheric conditions. And it is thermo-chemical process that converts biomass into liquid, charcoal and non-condensable gases and chemical by heating the biomass to about 500°C in the absence of oxygen.

Conventional Pyrolysis: Conventional pyrolysis is defined as the pyrolysis, which occurs under a slow heating rate. This condition permits the production of solid, liquid and gases pyrolysis products in significant portions.

Slow Pyrolysis: Slow pyrolysis of biomass is associated with high charcoal continent, but the fast pyrolysis is associated with tar, at low temperature (675-775K) and/or gas, at high temperature. at present, the preferred technology is fast pyrolysis at high temperatures with very short residence time.

Fast Pyrolysis: Fast pyrolysis (more accurately defined as thermolysis) is a process in which a material, such as biomass, is rapidly heated to high temperature in the absence of oxygen.

Flash Pyrolysis: The flash pyrolysis of biomass is the thermo-chemical process that converts small dried biomass particles into a liquid fuel (bio-oil or bio-crude) for almost 75% and char and non-condensable gases by heating the biomass to 775K in the absence of oxygen. Char in the vapour phase catalyzes secondary cracking.

Corresponding Author: M. Balamurugan, P.G Scholar, Mechanical Department, Pondicherry Engineering College, India.

Products of Pyrolysis:

- Gas 2. Char 3. Oil
- Advantages of Pyrolysis

Combustion Performance: The combustion processes for solid and the gases fuels can be more effectively separated and this allows the combustion condition for each to be closer to its ideal.

Low Dust Carry Over: The flue gas volume and the dust carry-over levels can be significantly reduced which results in a simplification of the downstream gas cleaning equipment.

Thermal Efficiency: The thermal balance is improved as a result of reduction in excess air required for incineration.

Feed Calorific Value: Feed materials with high calorific contents, does not cause any problem since the furnace temperature are readily controllable.

Low NO_x: As the Multiple Hearth Furnace is considered more or less as a fixed bed system (versus fluidized bed), this alone ensures that NO_x emissions are lower than in any other system.

Literature Review: Peter Mckendry [1] reviewed the main conversion process with specific regard to the production of a fuel suitable for spark ignition gas engines.

Graham *et al*. [2] made the studies on applications of rapid thermal processing of biomass. They found that the rapid thermal processing is a generic technology to convert carbonaceous feedstock to high yields of chemical and liquid fuels products. They also find that this method is suitable for short term application include the production of specialty chemicals, fuel oil substitutes and engine fuels for both the diesel and turbine engine applications.

Samolada *et al*. [3] Made the pyrolysis of biomass sample in the fluid bed reactor. They studied the effect of the experimental conditions on their yield, composition of the phenolic fraction of the liquids and pyrolysis gas. They found that the bed temperature acts as main factor, for co ntrol the yields of products and the bed temperature of approximately 700°C is recommended for max.yields.

Bridwater [4] reviewed the design consideration faced by the developers of the batch type pyrolysis, upgrading and utilization process in order to successfully implement the technologies. Here the aspect of batch type reactor is studied.

Boukis *et al*. [5] Made the experiments on circulating fluid bed reactor operators in relatively high velocity studied the hydrodynamic behavior of the designed reactor. They observed that circulating fluid bed hydrodynamic and stability

Wagenaar *et al*. [6] made experiments on rotating cone reactor and absorbed that the particles large than 400μm seem to be unaffected by the viscous forces because their mass inertia and the resistance time of such particles is hardly dependent on the particle diameter. If the particle diameter is smaller than 200μm the viscous become important compared to the mass inertia and the particle residence time is strongly dependant on the particle diameter.westerhout *et al*. [7] made the experiments on the techno economic evaluation of high temperature pyrolysis process for mixed plastics waste. From experiments it is observed that the rotating cone reactor is competitive with other types of gas-solid reactor such as bubbling fluid bed and riser system

Design of Pyrolysis Setup

Reactor Setup: Reactor is the place where the pyrolysis reactor takes place. The reactor is made up of stainless steel in order to avoid the corrosion resistance compare to mild steel.

Types of Reactors

- Ablative type reactor
- Circulating fluid bed type reactor.
- Fluid bed type reactor.
- Entrained flow type reactor

Desirable Parameters for the Design:

- *Melting point of the substance*: If mp is high, substance easily vaporizes & more oil is obtained.
- *Density*: If density is lower, substance easily vaporizes & more oil is obtained.
- *Moisture content*: More is moisture, less is the oil yield.
- *Reactor Temp*: More is the reactor temp, more is the yield

- *Heating rate*: More is the heating rate, more is the yield
- *Reactor size*: There is an optimum for the reactor size to get maximum oil yield.
- *Feed rate*: Feed rate is given according to the demand for the oil.

Calculation

$$\text{Volume of the reactor} = 3.14 \times r^2 \times h$$
$$= 3.14 \times 9 \times 9 \times 31$$
$$= 7.884 \times 10^{-3} m^3$$

Based on the density and volume of the biomass, the volume of the reactor is calculated as follows.

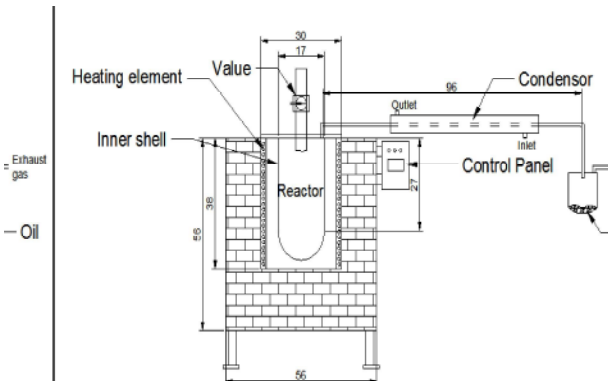

Fig. 5.1: Front view

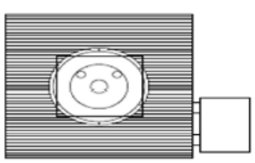

Fig. 5.2: Top view

Characterization of Biomass: The raw material is characterized as follows

- Thermogravimetric Analysis
- FTIR Analysis

Thermo-gravimetric Analysis: Thermo-gravimetric analysis was performed on a Q600 SDT TGA instrument for the stem, flower and leaf. Combustion runs were carried out in the inert atmosphere heating from 25 to 900 °C at a rate of 10°C/min. A sample of about 12.093 mg is taken for T.G.A. The temperature maintained for the sample is 25°C to 700°C at the heating rate of 10°C/min. in the TGA model of Q600SDT.

TGA of Water Hycanith Stem

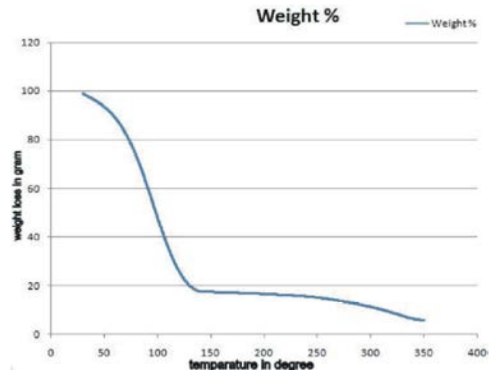

Fig. 6.1: TGA of water hyacinth stem

From the graph, it is seen that the sample has started decomposing from 300°C and the maximum decomposition occurs between 300ºC – 450ºC. Finally decomposition ends at 550ºC.

TGA of Banana Stem

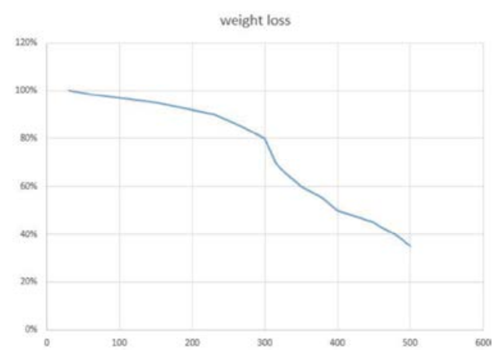

Fig. 6.2: TGA of banana stem

From the graph,it seen that the decomposition of the flower starts at 220°C and the maximum decomposition occurs between 220°C - 430°C.

TGA of Pseudo Stem:

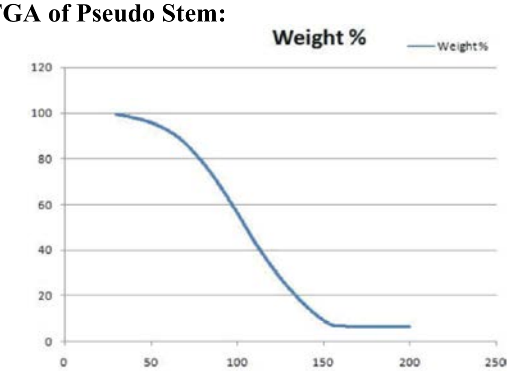

Fig. 6.3: TGA of pseudo stem leaf

From the graph, the decomposition of the leaf starts at 200°C onwards and the maximum decomposition occurs between 200°C - 400°C.

Fourier Transform Infrared Analysis:
FTIR For water hycanith
FTIR analysis result of water hycanith Bio-oil sample. The result are tabulated in Table 6.2

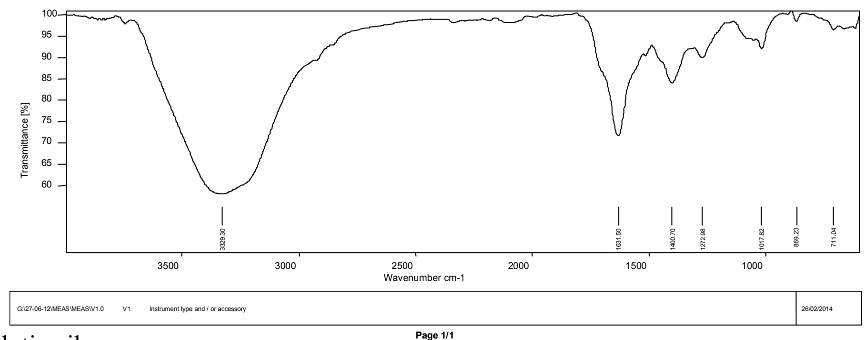

Fig. 6.4: FTIR of pyrolytic oil

Table 4.1: Components Present in the pyrolytic oil(Water Hycanith)

Peak value	Group name	Functions
3329.30	Alcohols	O-H stretch
1631.50	Ketones	C-O Bend
1400.70	Secondary Amines	N-H Bend
1272.98	Esters	C-O stretch
1017.62	Ethers	C-o stretch

Fourier Transform for Banana Stem

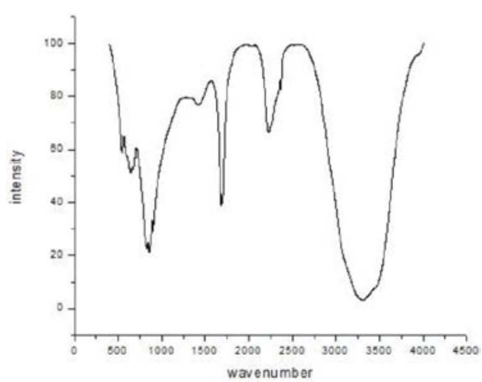

Fig. 6.5: Pyrolytic oil of Banana stem

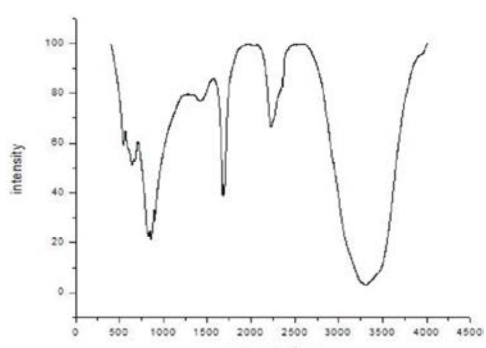

Fig. 6.6: Pyrolytic oil of Banana Pseudo Stem

Slow Pyrolysis of Various Biomass

Experimental Procedure: The stem of various biomass was cut into pieces and it is dried in the sunlight for 2-3 days. A sample weighing 250g was kept in the reactor. The biomass was heated to a maximum temperature from room temperature. When the maximum temperature was reached the reactor turns off automatically. When the reactor was completely cooled to room temperature, the char was removed from the The slow pyrolysis experiments were conducted at the following conditions.

- Reactor temperatures of 250°C, 350°C, 450°C, 550°C and 650°C with stem length of 3cm.
- Different stem lengths of 0.02cm, 2cm, 3cm and 20cm, keeping the reactor temperature at 550°C.
- By providing ice bath in the collecting tank in order to find the effect on the amount of oil collected.

RESULTS AND DISCUSSIONS

Pyrolysis at Temperature: The stem was subjectetd to the slow pyrolysis under different temperatures of 150°C, 200°C, 250°C and 300°C. The results of the process was given in terms of oil, char and

From the graph, it is seen that the maximum oil yield take place at 550°C, whereas char and gas yield is high at 150°C and 300°C respectively.

Pyrolysis Experiments by Using Ice-bath in Collecting Tank: The pyrolysis experiments were conducted by surrounding the collecting tank with ice bath and at reactor temperature of 550°C. A comparison of yields of different products with and without ice bath is shown in the Table 6.1. It is seen that the oil yield is increased by 20 percentages.

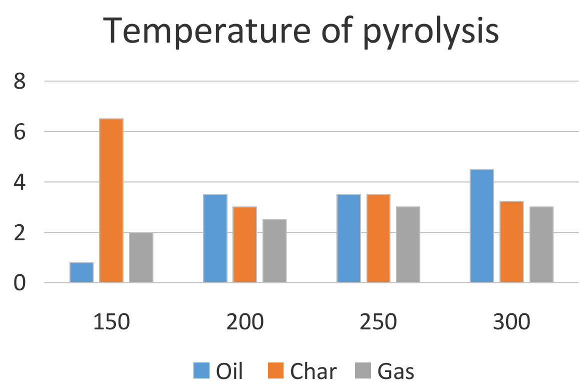

Fig. 8.1: Yield of the pyrolysis products at different temperature

Table 8.1: Variation in experiment by using ice bath

S.No	Without ice bath	With ice bath
Oil (%)	42.4	51.2
Gas (%)	25.6	16.8
Char (%)	32	32

CONCLUSION

In our project, pyrolysis of various biomass is carried out in circular slow pyrolysis reactor and using TGA curve the various decomposing temperature of Water hycanith, Banana stem, banana pseudo stem was found and the yields like char,oil,gas are obtained by varying with the temperature and particle size which describes lowering the temperature the char yield high and for increasing temperature the gas yield is high,in and the oil is at between. our setup consists of electric controller which reduces the power loss.

REFERENCES

1. Peter Mckendry, 2002. Energy production from biomass, 83: 47-54.
2. Graham, R.G., B.A. Freel, D.R. Huffman and M.A. Bergougnou, 1993. Applications of rapid thermal processing of biomass. In Advances in Thermmochemical Biomass Conversion, 2: 1275-1288. Blackie, London.
3. Samolada, M.C. and I.A. Vasalos, 1994. Effect of experimental conditions on the composition of gases and liquids from biomass pyrolysis". In Advances in Thermo chemical Biomass Conversion. 2: 859-873. Blackie Acadamic and Professional.
4. Bridgwater, A.V., 1999. Principles and practice of biomass fast pyrolysis processes for liquids". Journals of Analytical and Applied Pyrolysis. 51: 3-22.
5. Boukis, I., K. Maniatis, A.V. Bridgwater, S.Y. Kyritsis Flitris and V. Vassilatos, 1994. Flash pyrolysis of bio-mass in an air blown circulating fluidized bed reactor. In Advances in Thermochemical Biomass Conversion. 2: 1151-1164.
6. Brigwater, A.V. and G.V.C. Peacocke, 2000. Fast pyrolysis processes for biomass. Renewable and Sustainable Energy Reviews. 4: 1-73.
7. Wagenaar, B.M., J.A.M. Kuipers, W. Prins and W.P.M. Swaaij van, 1994. The rotating cone flash pyrolysis reactor, In: Advances in Thermochemical Biomass Conversion, 2: 1122-1133, Blackie Academic and Professional.