International Journal of Research in Advent Technology, Vol.6, No.8, August 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Vacuum Pyrolysis of bamboo, sawdust and writing paper

J V Bholanda
Mechanical Engineering Department, Government Polytechnic, Godhra affiliated to Gujarat Technological University, Ahmedabad
Email: iiitvadodara@gmail.com

Abstract-Vacuum pyrolysis is the thermal degradation of a cellulose, hemicelluloses and lignin feedstock in the absence of oxygen and under low pressure, to produce a bio-oil and char as main products, together with water and non-condensable gases. Both the pyrolytic oil and char have a high energy content and may be used as fuels..The Glassware experiment is performed and result produced gives real picture of %weight can be achieved through this thermo chemical process. It is approximate approach towards batch type Pyrolyser experimentation.

Index Terms-Vacuum Pyrolysis; pyrolytic oil

1. INTRODUCTION

The energy crisis and management of the increasing quantities of waste being generated in modern society are both hot issues, particularly for developing countries such as India. According to a report published by the Ministry of Urban Development , Government of India 10^{11} tons per day of MSW was generated in India in the year 2000[1]. This increased to $1.27x10^{11}$ tons per day in the year 2012. Of the aforementioned waste approximately 70% is collected and 12.45% is treated [CPCB, 2012].[2]

A non-segregated model is followed in the solid waste management system in India which accounts to presence of sand, silt , dust and moisture in the municipal solid waste with bio- degradable fraction being the major portion. The various components found in the waste include organic matter (40%), plastics (3.7%), paper (6%), glass (1.1%) and metals (0.52%), out of which paper, glass and metals are recyclable materials.[3]

Therefore, the organic matter is selected for the present study. A potential solution that addresses aforementioned challenge is to develop processes such as pyrolysis that are capable of converting waste into fuel. Pyrolysis is Therefore, the main aim of this work is to investigate the conversion of waste into fuel using pyrolysis

In regards to the reaction conditions, most pyrolysis processes have been conducted at atmospheric pressure. Vacuum pyrolysis has only been reported in studies of special wastes such as Scrape Tyres, Biomass, printed circuit board disposal.

Although vacuum pyrolysis is reported to shorten the residence time of volatile products in the high-temperature zone, reducing the secondary decomposition and increasing the heat value of the gas products, less possibility of oxidation.[4] Achieving vacuum pyrolysis is difficult in practice.

To prove the technology and study mechanism of Vacuum pyrolysis lab scale experimental set up is planned and data collected from experiment will prove itself.

2. OBJECTIVES

- Development of Laboratory scale glassware experimental set up of vacuum pyrolyser.
- To understand the most suitable/feasible vacuum pyrolysis technology for MSW in Indian scenario.

3. EXPERIMENT

Borosilicate glassware is used for lab scale experimentation with following procedure and set up. [5]

3.1. *Block diagram of experimental procedure*

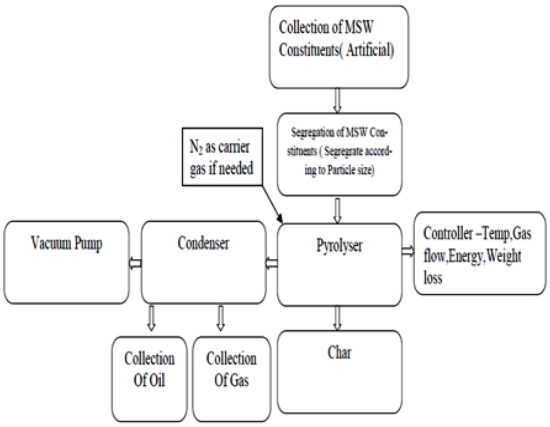

Fig.1Block Diagram of experiment procedure

3.2 Experimental set up

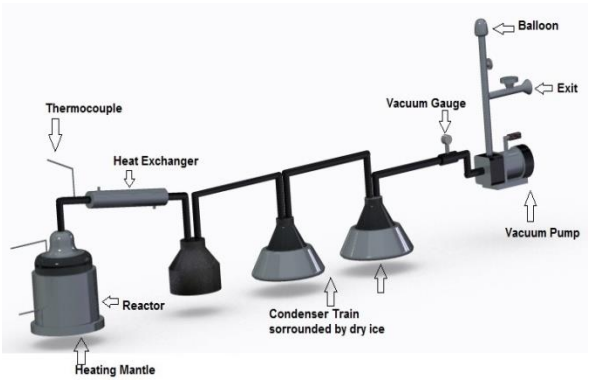

Fig.2 Pictorial view of Vacuum pyrolysis setup

Fig. 3 Vacuum pyrolysis Glassware setup with double shell Condenser

3.2. *Experimental Procedure*

- Reactor is placed on heating mantle.
- Reactor is crowned by sinter glass disc.
- The temperatures of the furnace and sample will be measured by the two thermocouples inside reactor tube and the data will be logged.
- Double surface condenser is attached at exit of reactor.
- Condensers, connected by thick walled rubber tubing, will be used for the capture and condensation of released volatiles.
- Condenser (vacuum traps) are placed in beakers filled by ice and dry ice.
- Sample of 10o g will be placed into the reactor for each run.
- After loading, the reactor will be sealed and evacuated.
- Condenser are kept at progressively colder temperature
- The vacuum pump removes the organic vapours and gas products from the reactor through the condensation train.
- Non condensable gases will be measured by collecting it in balloon.
- Non condensable gases will vent into the air.
- After reaction is complete valve will be kept closed till atmospheric temp is achieved to prevent oxidation of char.
- After experiment liquid, solid yield will be weighed

3.3. *Problem encountered during Glassware Laboratory Set up*

- ❑ Pinching of soft rubber tubes
- ❑ Due to blockage at bends of glass of vacuum was not achieved
- ❑ Leakages in vacuum trap bottles
- ❑ Hard tube has larger dia
- ❑ Early condensation on bends
- ❑ Early condensation in Double shell condenser

Fig. 4 Modified Vacuum pyrolysis Glassware setup

3.4. *Problems during experimentation*

- Loading of 100 gram sample was troubling as heating mantle start to fuse and heater of heating mantle was replaced twice
- Same experiment for 20 to 50 gram sample was giving smooth pyrolysis
- Early condensation at bend of glassware starts
- Long piping for convenience of arranging set up was creating issues for getting desirable vacuum.
- Instead of thermocouples, Infrared Thermometer is used.

Fig. 5 Bamboo Vacuum pyrolysis

Fig.6 Early condensation on bend

4. RESULT

After modification in set up for each sample pyrolysis parameters and yield are listed and tabulated.

4.1. *Vacuum pyrolysis of sawdust*

- Sample Weight: 30 gm(Sevan+ Pine wood)
- Particle Size : Coarse
- Pyrolysis Time : 60 min
- Final Pyrolysis Temperature : 270 ^{0}C
- Vacuum: 700 Torr (8 kPa)
- Temperature of Condenser Train : Cond1 : 2 ^{0}C Cond 2 : 4 ^{0}C
- * Gas weight is calculated on difference basis

Table 1: Mass balance of yield products of sawdust

Sample Type	**Yield**		
Sawdust	Char	Pyrolotic Oil	Gas*
Weight (gm)	8	16	6
% weight	26.67	53.33	20.00

4.2. *Vacuum pyrolysis of Bamboo*

- Sample Weight: 30 gm
- Particle Size : Fine
- Pyrolysis Time : 60 min
- Final Pyrolysis Temperature : 285 ^{0}C
- Vacuum: 700 Torr (8 kPa)
- Temperature of Condenser Train : Cond1 : 3 ^{0}C ,Cond 2 : -4 ^{0}C

* Gas weight is calculated on difference basis

Table 2: Mass balance of yield products of bamboo

Sample Type	**Yield**		
Bamboo-1	Char	Pyrolotic Oil	Gas*
Weight (gm)	8	19	3
% weight	26.67	63.33	10.00

- Sample Weight: 50 gm
- Particle Size : Fine
- Pyrolysis Time : 60 min
- Final Pyrolysis Temperature : 270 ^{0}C
- Vacuum: 700 Torr (8 kPa)
- Temperature of Condenser Train : Cond1 : 4 ^{0}C ,Cond 2 : 6 ^{0}C

Table 3: Mass balance of yield products of bamboo

Sample Type	**Yield**		
Bamboo-2	Char	Pyrolotic Oil	Gas*
Weight (gm)	15	26	9
% weight	30	52	18

4.3. *Vacuum pyrolysis of writing paper*

- Sample Weight: 25 gm
- Size: 1sqcm
- Pyrolysis Time : 30 min

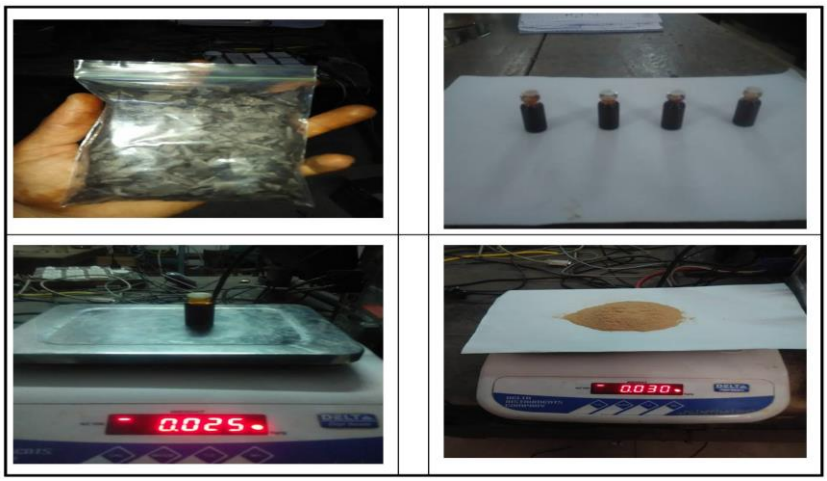

Fig. 7. Measurement and display of Yield products of samples.

- Final Pyrolysis Temperature : 195 ^{0}C
- Vacuum: 700 Torr (8 kPa)
- Temperature of Condenser Train : Cond1 : 6 ^{0}C ,Cond 2 : 7 ^{0}C

Table 4: Mass balance of yield products of paper

Sample Type	**Yield**		
Paper 65 GSM	Char	Pyrolotic Oil	Gas*
Weight (gm)	10	8	7
% weight	40	32	28

5. CONCLUSION

Displayed results are only to understand how much different yields are obtained. It is approximate approach towards batch type Pyrolyser experimentation. After completion of pyrolysis yields were weighed. It is observed that Oil yield for smaller particle is more and bigger is sample size, gas yield is more. There is High char yield due to incomplete pyrolysis of newspaper. Moreover Moisture presence in tar is visible.

There is limitation of temperature in borosilicate glassware experiments and In Glassware Pyrolyser heating rate cannot be regulated.

Data collection of temperature and weight loss throughout pyrolysis process is not available for analysis.N2 is not required as carrier gas during pyrolysis process in Glassware laboratory set up and BVP. Data collected by glassware vacuum pyrolyser is useful in the modelling, design, operation and understanding of batch type vacuum pyrolyser and problems encountered during design, development and fabrication of glassware pyrolyser helps to develop and fabrication of batch type vacuum pyrolyser.

REFERENCES

[1] Central Pollution Control Board(CPCB) "Management of municipal solid waste". Ministry of Environment and Forests (MoEF), New Delhi, India, 2004.

[2] Central Pollution Control Board(CPCB)" Status report on municipal solid waste management." Ministry of Environment and Forest (MoEF), New Delhi, India, 2012.

[3] Agarwal Manu._"An investigation on the pyrolysis of municipal solid waste". RMIT University, 2014.

[4] C Chen, D., Yin, L., Wang, H., & He, P. "Pyrolysis technologies for municipal solid waste: A review". Waste Management, 34:12, 2466-2486, 2014.

[5] Sadanand A Namjoshi."Pyrolysis Kinetics & Product analysis of municipal solid waste constituents". Thesis for the degree of doctor philosophy, SVNIT, Surat,2013.