"Design Consideration Of Pyrolysis Reactor For Production Of Bio-Oil"

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***Abstract*— Conversion of agricultural residue to usable energy forms has gained much interest recently due to increase in energy cost as well as greater pressure on the environment by the use of fossil fuels. Thermo chemical conversion processes such as pyrolysis and gasification are some of the promising options that may be applied to effectively utilize agricultural wastes as source of energy production. In this experimental work, a fixed bed reactor is designed to evaluate the thermo chemical conversion process. This paper attempts to discuss the generalized design consideration for fixed bed pyrolysis reactor.**

KeyWords: Pyrolysis reactor, bio-oil, agricultural waste.

I.INTRODUCTION

Environmental concerns and possible future shortages have boosted research into alternatives for fossil-derived products. Agricultural waste is easily available worldwide and considered to be renewable. The demand of energy from fossil is growing at high rate due to the development of all aspects of the world and the utilization of the fossil fuel generating the environmental problems. There is need for identifying the sustainable energy options for energy production without polluting the environment. The renewable energy source can play a major role for sustainable development. Among the possible renewable energy options, agriculture and forest residues (generally called as biomass) can be used as a raw material to generate energy.

Many researchers have been reported some materials were converted to bio-oil such as tea residue, safflower seed residue, rise husk, sugarcane bagasse, coconut shell, empty fruit bunches etc.

II. BIO-OIL

Bio oil is a dark, viscous liquid with the same elemental composition of biomass. It is not actually "oil" in the traditional sense; bio-oil is made up of many different oxygenated organic compounds and will not mix with traditional petroleum fuels. This is because of its large water content: 15-20%, which serves to suspend several hundred different molecules in what scientists call a "micro-emulsion." Crude bio-oil can be used in home heating and large-scale electricity generation, or refined into more efficient fuels and certain industrial chemicals. It is likely the high variability of crude bio-oil that gave it its name. Like petroleum oil, bio-oil can be refined and molded into a wide variety of fuels and chemicals.

Bio-oil is an attractive alternative energy source for many reasons. Most notably, it is completely renewable and easily created from common waste products. Using biomass feedstock such as wood, the pyrolysis process results in "net zero" carbon dioxide emissions and no sulfoxide emissions.

III. TYPES OF PYROLYSIS REACTORS

Various types of pyrolysis reactors were designed for production of bio-oil from different agricultural wastes. Some of these reactors are,

1- Fixed bed reactor
2- Free fall reactor
3- Fluidized bed reactor
4- Induction heating reactor
5- Fixed bed catalytic reactor

Out of these reactors fixed bed reactor is easy to construct, cheap and requires less maintenance.

IV.BASIC CONSIDERATION FOR SELECTING PYROLYSIS REACTOR

1. Type of reactor
2. Material of construction that can be with-stand at high temperature.
3. Diameter of reactor
4. Height of reactor
5. Feed material used with their particle size
6. Rate of heating in ^{o}C/min
7. Insulation material
8. Temperature sensing element

V.DESIGN AND CONSTRUCTION OF PYROLYSIS REACTOR

A. System components

The essential components of pyrolysis system have been identified. The schematic diagram of pyrolysis system is shown in fig.1.

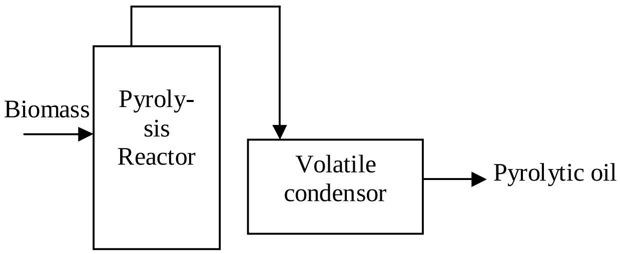

Fig.1. System components of reactor

B.Pyrolysis Reactor

The pyrolysis reactor is designed for pyrolysis of waste materials like biomass, agricultural wastes, scrap types etc. The reactor is a cylindrical, batch type, fixed bed reactor. The top side of reactor can be open for feeding the raw material and solid residue (char) can be removed at the end of the experiment. The temperature inside the reactor is measured by using K-type thermocouple. During the reaction, the top side is kept closed by a cover plate tightly secured to the flanged opening. This prevents ingression of atmospheric air into the reactor, thereby achieving pyrolysis conditions. The reactor weighs approximately 20-25 kg. The pyrolyser is provided with ceramic wool insulation on the outer side to prevent the heat loss to the surrounding. An exit pipe at the side carries away the evolved gases during pyrolysis. The temperature inside the reactor is measured by a thermocouple.

C.Electrical Heater

An electrical heater is provided inside the reactor for thermal degradation of agricultural waste. The thermal degradation of waste is caused by electrical heating. The heater is rated 3Kw. The heater is made up of Canthel wire wound in the form of coils arranged vertically in ceramic blocks. Temperature requirement is different for different waste materials.

D.Volatile condensor

A volatile condensor is provided for condensation of volatile gases which is then known as bio-oil or Pyrolytic oil. Hot gases passed through the inside tube of condensor and condensed with the help circulation of cold water surrounding the tube.

E.Instrumentation

The instrumentation panel consists of a fuse unit, MCB, on-off switch, temperature controller. The temperature of the Pyrolyser is measured by a K- type thermocouple connected to a digital temperature indicator of1°C accuracy. The time is measured by a digital timer of 0.01 second accuracy. The weight of input feedstock and residue after pyrolysis are measured by a digital weighing balance of 1g accuracy.

The overall arrangement of the components is shown in the figure2.

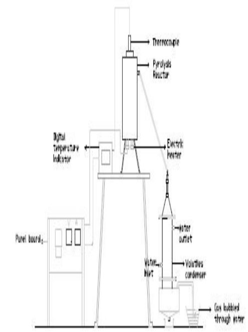

Fig.2.Overall experimental set-up

VI. EXPERIMENTS

The experiments will be conducted by maintaining the pyrolysis reactor under various conditions. Pyrolysis process will be carried out by changing the parameters like temperature, heating rate, feedstock particle size, amount of feed material etc.

Different temperature conditions and heating rate are required for different feed and types of pyrolysis. Ex. For slow pyrolysis temperature requirement is 250 to 500^{o}C and heating rate is about 10 – 20^{o}C/min. Whereas for fast pyrolysis temperature requirement is maximum and heating rate required is 100^{o}C/sec and above.

Various parameters will be studied to find out the condition where maximum yield will obtained.

VII. CONCLUSION

The reactor is easy to install and requires less maintenance. The reactor is having greater stability at high temperature. The reactor system does not require any complicated components and easy to study at various conditions.

REFERENCES

1] Natarajan E. and Sundaram G.E. (2009) Pyrolysis of rice husks in a fixed bed reactor. World Academy of Science, Eng. Techn., vol. 56.

2] B. B. Uzun and et. Al. “Synthetic fuel production from tea waste: Characterization of bio-oil and bio-char”. Journal of Fuel. Sep. 2009, pp. 176-184.

3] S. Sensoz and D. Angın. “Pyrolysis of safflower (Charthamustinctorius L.) seedpresscake in a fixed-bed reactor: Part 2. Structural characterization of pyrolysis bio-oils” Journal of Bioresource Technology. Dec. 2007, pp. 5488-5504.

4] Mh.Rofiqul Islam and Mh.Nurul Islam (2003) Fixed Bed Pyrolysis of Sugarcane Bagasse For liquid fuel production. International conference of mechanical engineering (ICME2003).

5] J.T. Alberto, Weihong Yang, Wlodzimierz Blasia, “Pyrolysis characteristics and global kinetics of coconut and cashew nut shells,” Fuel Processing Technology, vol 87, pp. 523-550, 2006.

6] Abdullah, N. and H. Gerhiouser, 2008. Bio-oil derived from empty fruit bunches. Fuel 87: 2606-2613

7] Slow pyrolysis of banana culture waste: leaves and pseudostem e. r. k. Fernandes1, C. Marangoni1, 2, S. H. W. Medeiros1, 2, 3, O. Souza1, 2, 3 and N. Sellin1, 2, 3.

8] The Utilization of Waste Date Seed as Bio-Oil and Activated Carbon by Pyrolysis Process Mohammad UzzalHossain Joardder,1 Md. Shazib Uddin,1 and Mohammad Nurul Islam2 muhjoardder@gmail.com Received 22 March 2011; Revised 26 September 2011; Accepted 3 October 2011 Academic Editor: HyungHee Cho.

9] GOB. 2001, 1999 Statistical Yearbook of Bangladesh, Dhaka: Bangladesh Bureau of Statistics, Statistical Division of Ministry or Planning.

10] Bridgwater, A.V., D. Meier and D. Radlein, 1999. An overview of fast pyrolysis of biomass. J. Organic Geochem. 30: 1479-1493. DOI: 10.1016/S0146-6380(99)00120-5.

11] Fixed Bed Pyrolysis of plum seed Waste for Liquid Oil Production Mohammad Nurul Islam, Mohammad UzzalHossainJoardder,, Md. MasudParvez and NayanKanti Deb

12] P. A. Horne and P. T. Williams, “Premium quality fuels and chemicals from the fluidized bed pyrolysis of biomass with zeolite catalyst upgrading,” Renewable Energy, vol. 5, no. 5-8, pp. 810–812, 1994.

13] Blasi C.D., Signorelli G., Russo C.D., and Rea G., ”Product distribution from pyrolysis of wood and agricultural residues,” Ind. Eng. Chem. Res., Vol. 38 ,pp. 2216–2224, 1999.

14] Pyrolysis of Coconut Shell: An Experimental Investigation E. GanapathySundaram*a and E. Natarajanb *a Department of Mechanical Engineering, Velammal Engineering College, Chennai 600 066, Tamilnadu, India Institute for Energy Studies, College of Engineering, Anna University, Guindy, Chennai 600 025, Tamilnadu, India

15] Arso, A. and M. Iino, 2007. Effect of amines added on Banko coal liquefaction. J. Fuel Process.Technol, 88: 813-816. DOI:10.1016/j.fuproc.2007.04.002.

16] S. Sensoz and D. Angın. “Pyrolysis of safflower (Charthamustinctorius L.) seedpresscake in a fixed-bed reactor: Part 2. Structural characterization of pyrolysis bio-oils” Journal of Bioresource Technology. Dec. 2007, pp. 5488-5504.

17] V. Boonamnuayvitaya and et. Al. “The Preparation and Characterization of Activated Carbon from Coffee Residue” Journal of Chemical Engineering of Japan. Vol.37, 2004, pp. 1504-1512.

18] Ji-Lu, Z., 2007. Bio-oil from fast pyrolysis of rice husk: Yields and related properties and improvement of the pyrolysis system. J. Anal. Appl. Pyrol., 80: 30-35. DOI: 10.1016/j.jaap.2006.12.030.

19] Sensoz, S., 2003. Slow pyrolysis of wood barks from PinusbrutiaTen and product compositions. J. Biores. Technol., 89: 307-311. DOI: 10.1016/S0960-8524(03)00059-2.

20] Tsai, W.T., M.K. Lee and Y.M. Chang, 2006. Fast pyrolysis of rice straw, sugarcane bagasse and coconut shell in an induction-heating reactor. J. Anal. Appl. Pyrol., 76: 230-237. DOI: 10.1016/j.jaap.2005.11.007.