USING PYROLYSIS OF BIOMASS FOR PRODUCTION FUELS AND GASES FOR ENERGETICS

Samuel Bucko, Martin German-Sobek, Marek Pavlík, Jozef Király Matúš Novák

ABSTRACT

The Pyrolysis method for biomass processing was presented in this paper. One from lot of methods for comparing kinds and properties of biomass in pyrolysis process was selected thermogravimetric analysis (TGA). The aim of this paper is presenting current research in pyrolysis from agricultural countries. In general, using of biomass can be convenient, primarily in developing countries for fulfillment international emission standards.

1. INTRODUCTION

Condition of climate, strict emission standards and problem with wasting non-renewable energy sources (petroleum, natural gas and coal) are reasons for searching new solution in development of power, for researchers and producers of electric energy. One of solution is using biomass. However it must fulfil the conditions to energetic efficiency. The biomass would mainly consist of waste from animal production and agriculture. It wouldn't be on the expense of food production (energetic crops instead of food crops), decrease of forest area and other. It has to be economically advantageous and environmentally friendly.

Pyrolysis method is enough known in present. Research is focused on increasing of efficiency produce of energy. In most countries especially those agricultural countries where are many agriculture or timber harvesting and from these industries can be obtained straw and wood dust, which is a considerable amount of energy. Hence, taking full advantage of biomass can certainly benefit the global energy status.

The method of biomass utilization can be mainly divided into three categories: combustion, gasification and pyrolysis. Among which, pyrolysis can produce charcoal, tar or biogases, which are convenient and useful fuels or chemicals. In this way, biomass can be used in varies fields conveniently and efficiently. Moreover, pyrolysis also acts as the first step of combustion and gasification.

2. BIOMASS PYROLYSIS

Pyrolysis as the oldest and simplest means to convert biomass into liquid or gaseous fuels or chemicals is the previous stage of many thermal chemical processes, staying in the heart of all thermal conversion processes.

Pyrolysis is the chemical decomposition of condensed organic materials by heating in a reactor, largely in the absence of oxygen. The Pyrolysis mainly uses straw, branches, sawdust and other agricultural and forestry waste as raw material and, through high temperature and pressure, forms the raw materials into a variety of products. Depending on the pyrolysis method, residence time, the temperature to which the biomass is exposed, and the characteristics of the biomass, varying proportions of gas, liquid and solid products can be produced. The four main end products of pyrolysis include:

- **Biochar**
  Biochar is produced at low temperatures (less than 450°C) with a relatively slow heating rate.

- **Wood Vinegar**
  Bio oils are produced at an intermediate temperature and under relatively high heating rates and can be turned into wood vinegar.

- **Creosote**
  Creosote can also be produced from Bio oils

- **Electricity**
  Methane gas is produced at high temperatures (greater than 800°C) with rapid heating rates. Methane can be collected and transformed into electricity.

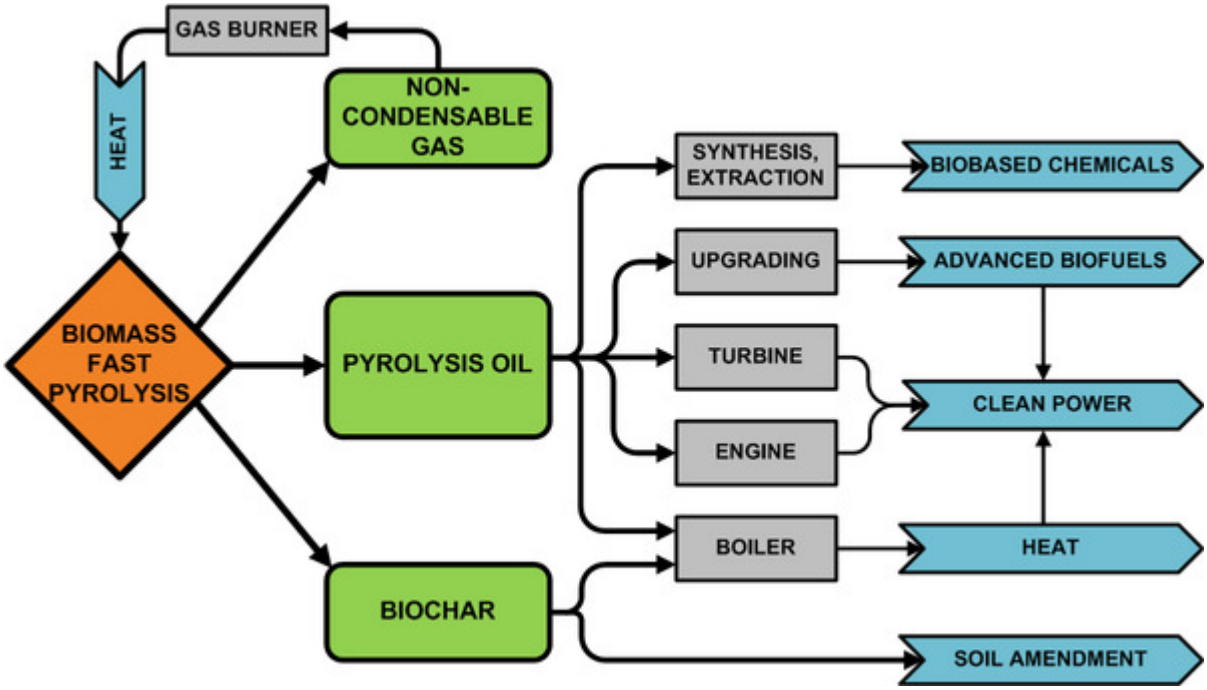

Figure 1 Process of pyrolysis

3. BIOMASS THERMOGRAVIMETRIC STUDY

Thermogravimetric Analysis is a technique in which the mass of a substance is monitored as a function of temperature or time as the sample specimen is subjected to a controlled temperature program in a controlled atmosphere.

Thermogravimetry is method for examination weight of sample as temperature function. The sample has been exposed by controlled thermal program. Main parts of device are constituted by thermo-balance, oven with controlled regulation of temperature program and thermocouple. Thermo-balance with sample must have continuous registration of weight, m = f (T) or f (t). Correctness, accuracy and sensitivity of thermogravimetry results are affected by many properties of thermo-balance and properties of sample. For example:

- Accuracy, sensitivity and inertia of mechanism for weighting and registering

- Oven atmosphere for create an oxygen-absent gas background
- Rate of change temperature at analysis
- Method of sample temperature measure
- Mass, grading and modification of sample
- Heat conductivity of sample

With thermogravimetry - TG is recorded also curve of differential thermogravimetry - DTG. The DTG expresses dependence of rate of change sample weight on temperature, i.e. dm/dt = f (T) or f (t). By DTG curve can be more precisely evaluation of thermal intervals with weight changes registered primary by TG curve.

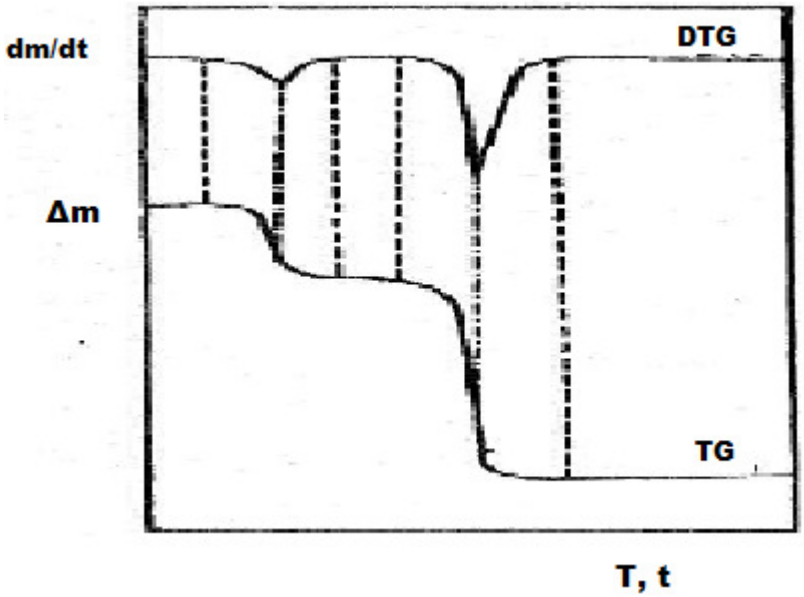

Figure 2 Example of TG and DTG curves

The thermogravimetric record is evaluated from start to end of deviation DTG curve, which is associated with weight change (i.e. places with "zero" speed of phenomenon). Maximum of DTG curve agree with point of inflexion TG curve. From this knowledge can be obtained data about amount of weight changes of sample and in which thermal interval are these changes happen. It also offer data about duration of process and its character with certain weight change under fixed conditions (e.g. speed of heating). Average speed of heating is given by ratio weight change to a time interval in certain terms of experiment. Curve of DTG is a set of points actual speeds of specific reactions (associated with weight changes). From this curve can be evaluated, with known parameters, speed in arbitrary point, e.g. maximum speed in certain peak of DTG curve.

Results from TG are used for reviewing of thermal degradation or also substance synthesis, evaluation of purity, representation of phases, assignment kinetic parameters of used heating programs and other.

4. RESEARCH OF PYROLYSIS

China is one of most significant representative in research of pyrolysis. There is wide area for growing crop and advanced timber production. The waste from harvest can further be used as a biomass.

In papers by FAN et al. are compared eight kinds of biomass for pyrolysis. They found that different biomass species have almost similar TG or DTG curves with partial diversity existed. They studied changes in TG and DTG with several factors affect the pyrolysis property of biomass in different ways. Higher heating rate or pressure disfavors biomass pyrolysis. Acting as an additive, the

presence of silicon dioxide, diatomite or limestone restrains the biomass pyrolysis rate and the efficiency is considerable, with the proportion of additives is increasing. But decreasing the particle size supports the pyrolysis of biomass.

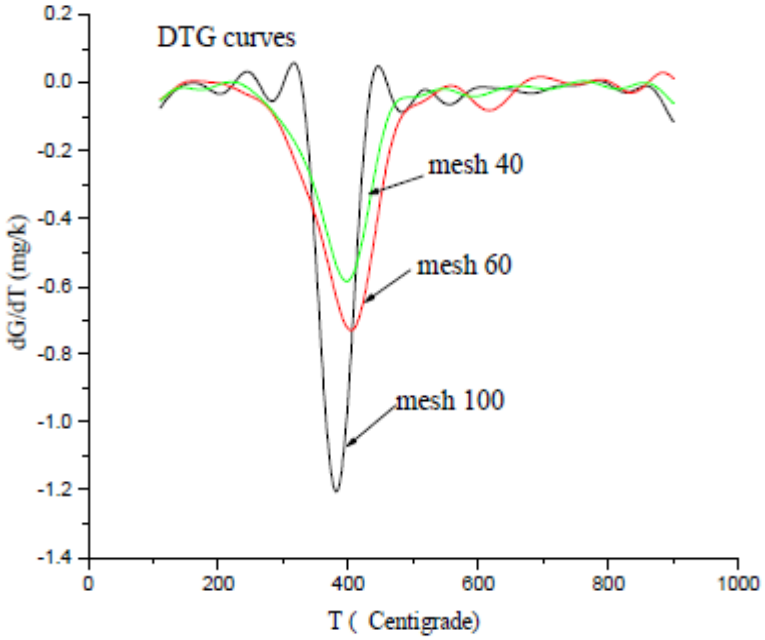

Figure 3 The DTG with different size of burning particles by Fan

Z. Song from Shandong University in China dealt to pyrolysis with used microwave heating. He experimented with straw bales of different weight and different input power of microwave heating. From his results is apparent that the microwave input power has considerable effect on the pyrolysis of straws, and the time to the maximum reaction rate is longer at lower input power.

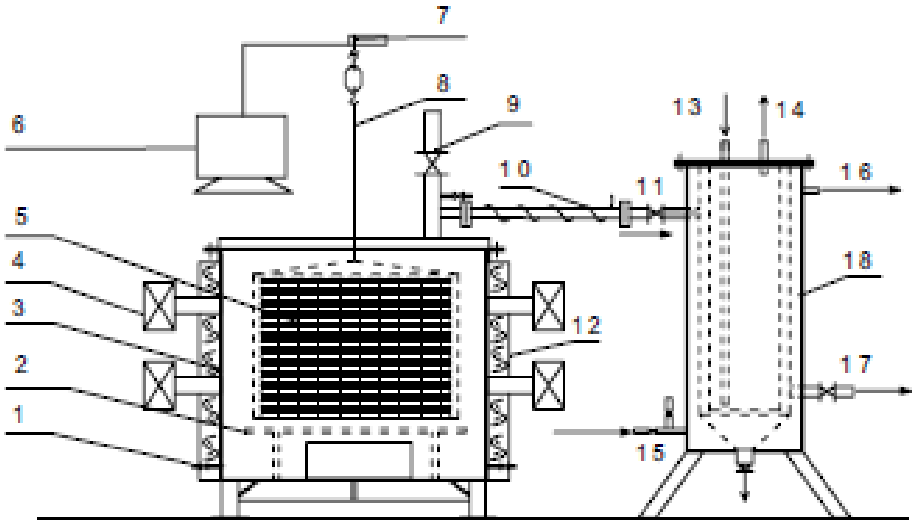

Figure 4 Device for pyrolysis with microwave heating from Shandong Univ.

1 – N_2 inlet, 2 – tray, 3 – insulating course, 4 – microwave generator, 5 – straw bale, 6 – data acquisition system, 7 – mass measurement sensor, 8 – hanging rod, 9 – gas collection, 10 – assistant heating system, 11 – gas inlet, 12 – microwave oven, 13,15 – cooling water inlet, 14, 16 – cooling water outlet, 17 – gas outlet, 18 – condenser

Li from China, Beijing found that UF resin in adhesive wooden blocks had no influence on the pyrolysis behavior of different components before the temperature of 200 °C. After 200 °C, the influence of UF resin mainly performed on cellulose and lignin among the three main components of biomass. For hemicellulose, UF has little impact.

5. CONCLUSIONS

Pyrolysis is appropriate method for biomass processing in agricultural countries. These countries investing lot of means to research have sufficient amount waste from agricultural harvesting (soya, grain, corn, rice) and timber harvesting (sawdust, leafs). Pyrolysis in countries with low level agricultural production could be focused on processing and utilization of municipal waste. Some kinds of plant biomass are applicable for direct combustion and substitution coal. The others are appropriate for production alternative fuel and then it can be used as fuel in motors or secondarily for electric power generation. Many aspects have influence on process of pyrolysis. Thermogravimetry is appropriate method for analysis of kinds of biomass, some additives, method of combustion and others.

REFERENCES

[1] Lan Tang; Huan Wang; Haiqing Hao; Yunhe Wang; Haitao Huang, "Plasma Pyrolysis of Biomass for Production of Gaseous Fuel to Generate Electricity," *Power and Energy Engineering Conference (APPEEC), 2010 Asia-Pacific* , vol., no., pp.1,4, 28-31 March 2010

[2] Zhanlong Song; Xiqiang Zhao; Chunyuan Ma; Tao Wang; Longzhi Li, "Kinetics of Pyrolysis of Straw Bales by Microwave Heating," *Power and Energy Engineering Conference, 2009. APPEEC 2009. Asia-Pacific* , vol., no., pp.1,5, 27-31 March 2009

[3] Zhi-lin Fan; Jun Zhang; Yao-ming Zhang; Li-guo Sun; Xiao-hui Liu, "Experimental study on pyrolysis property of eight kinds of biomass," *Sustainable Power Generation and Supply, 2009. SUPERGEN '09. International Conference on* , vol., no., pp.1,6, 6-7 April 2009

[4] Xuefeng Bai; Wei Wu, "Pyrolysis of Ligno-cellulosic Biomass from Northeast China," *Green Technologies Conference, 2010 IEEE* , vol., no., pp.1,6, 15-16 April 2010

[5] Mi Tie; Xinming Yu, "The Pyrolysis Characteristics of Four Kinds of Agri-Forestry Biomass Waste," *E-Product E-Service and E-Entertainment (ICEEE), 2010 International Conference on* , vol., no., pp.1,4, 7-9 Nov. 2010

[6] Dongyu Chen; Yanqing Hu; Qingyu Liu; Qing Sun; Yi Li; Min Zhang; Jinyang Li, "Decomposition characteristics and mechanism study of pretreated sunflower stalk," *World Automation Congress (WAC), 2012* , vol., no., pp.1,4, 24-28 June 2012

[7] Sijin Li; Shihua Chen; Jun Mu, "Influence of UF resin on pyrolysis characteristics of biomass components: A thermogravimetric study," *Biobase Material Science and Engineering (BMSE), 2012 International Conference on* , vol., no., pp.20,23, 21-23 Oct. 2012

[8] Natarajan. E and Ganapathy Sundaram. E,"Pyrolysis of Rice Husk in a Fixed Bed Reactor," *World Academy of Science, Engineering and Technology, International Science Index 32*, 3(8), 467 – 471, 2009

[9] Sučík, G., Vadász, P.: Žiaruvzdorné materiály - laboratórne cvičenia. 2008