Municipal Solid Waste and Dielectric Heating

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ABSTRACT

According to the population of urban area and the production of municipal solid waste (MSW) keep growing, the MSW disposal has become serious problem. There are basically two types of MSW that have opportunities for energy recovery such as solid waste and bio-solids. MSW has both organic and inorganic composition that are consisting of waste from kitchen, paper and wood waste, rubber and leather, plastics, glass, ferrous and non-ferrous metals, and so on. In this paper, the authors aim to the organic portion of MSW concerning about energy generation potential by utilizing various techniques. Physiochemical conversion as pyrolysis has been interested involving dielectric heating. The advantages of dielectric heating are fast process speed, high efficiency of energy conversion compared with the conventional methods.

Keyword: *Municipal Solid Waste (MSW), dielectric heating, energy conversion.*

1. INTRODUCTION

With the rapid development of developing countries, the accelerating urban area and continuous improvement of residence, the yield of MSW have been dramatically increased. Therefore, technologies for waste treatment are an important for the development of cities around the world. The difficulties associated with MSW disposal have become the serious problem for the future generation of areas which are having high population density [1], [2].

Pyrolysis is an endothermic process that induces the thermal decomposition of feed materials without oxygen [3], [4]. Temperature used for pyrolysis is between 400 and 650°C. At lower temperature, pyrolysis usually produces more liquid products, whereas higher temperatures produce more gaseous products. Pyrolysis based on dielectric heating is being investigated mainly for homogeneous wastes as sludge, shredded plastics and rubber [1]. The main advantages of dielectric heating include rapid, efficient in volumetric heating for direct coupling of energy with the molecules, easily controlled and maintained desired temperature [5].

In this paper, a general view of MSW and dielectric heating are described briefly. Some technologies based on dielectric heating are presented in various properties concerned with MSW.

2. MUNICIPAL SOLID WASTE (MSW)

MSW is a series of heterogeneous materials, whose chemical characteristics relate closely with the chemical properties of the various constituent components. The primary sources of MSW are classified as residence, institutional area and commercial waste [6], [7]. Typically, MSW consist of two categories as organic and inorganic wastes. The organic wastes include food and fruit waste, paper, wood waste, and so on. For the inorganic wastes are as plastics, foam, textile, ferrous and non-ferrous metals, batteries, waste from construction and glass. So, the organic portion of MSW has energy generation potential which can be utilized by various conversion techniques.

The composition of MSW is complicated and is impacted by a number of factors. Typically, the physical components of MSW are in food residue, non-combustibles, plastics, paper, textiles, wood waste, and rubber [6]. In food residue, the average elementary hydrogen (H), oxygen (O) and nitrogen (N) content varied greatly with samples and the chlorine (Cl) and moisture contents are extraordinarily high. The components of wood waste are simple and different components in characteristics. The element compositions of paper and textiles are also simple. The properties of chlorine-free plastics (such as polyethylene: PE, polypropylene: PP and polystyrene: PS) are consistent pattern, with high volatile matter, carbon (C) and H content [8], [9].

3. DIELECTRIC HEATING

Dielectric heating is different from conventional heating. The conventional methods depend on the slow heat from the surface of material to the interior determined by differential in temperature from a hot outside to a cool inside [5] as shown in Figure 1. Heating with dielectric energy is bulk heating in which the electromagnetic field interacts with the material as a whole. However, the rapid heating is an advantage of dielectric heating compared with conventional heating methods.

A list of some advantages of dielectric heating includes the following:

1) Speed of process is increased.
2) Uniform heating may occur throughout the material.
3) As efficiency of energy conversion, the energy couples directly to the material that is heated. This leads to significant energy savings.
4) Selective heating may occur. The electromagnetic field generally couples into the solvent. Hence, it is the moisture that is heated and removed.

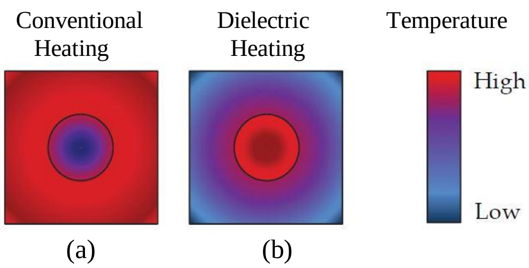

Fig. 1 *Quality comparison of temperature gradient within samples heated by (a) conventional heating and (b) dielectric heating. While the circles represent the sample, the squares correspond to the cavity used in both heating systems [4].*

4. DIELECTRIC SYSTEMS

Dielectric energy is usually applied by means of electrodes, in which the field oscilates through load [5]. There are three basic categories of electrodes as illustrated in Fig. 2.

The platen type usually consists of flat plates in pairs, between which the work piece may be held in a batch system or pass on a conveyor belt. This is useful for bulky objects. With the stray field type, the load passes over the electrodes of alternating polarity. Since the load represents the path of least electrical resistance, the dielectric field passes through it, causing heating. The staggered type is usually used for sheet materials and thick webs. The distance between the electrodes is kept to a minimum in order to achieve heating without arcing. The entire system is confined within a metal housing to prevent leakage of radiation.

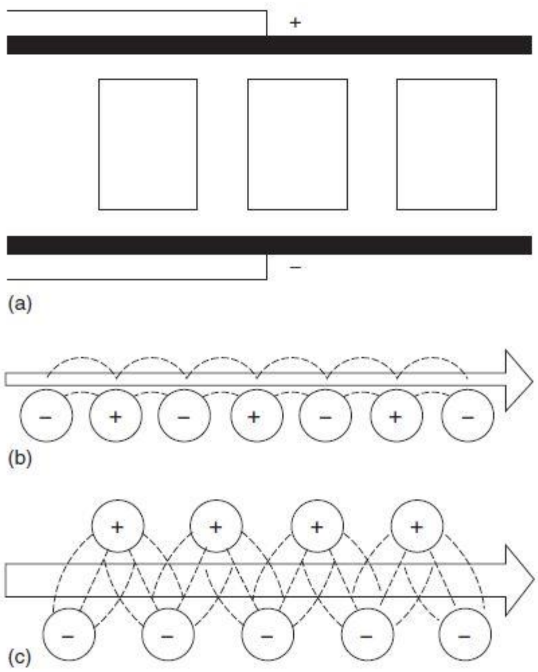

Fig. 2 *Electrode configurations for dielectric heating system: (a) platen type for bulky objects; (b) stray field type for thin webs; (c) staggered type for thick webs or board [5].*

5. PYROLYSIS OF MSW BASED ON DIELECTRIC HEATING

5.1 Pyrolysis of MSW for Syngas Production

In [3], the application of electromagnetic-irradiated pyrolysis of MSW for total recovery of useful gases and energy are studied. The percentage of composition different fraction in MSW and proximate analysis of MSW are shown in Tables 1 and 2, respectively. The MSW sample holder was placed into the sample holder as shown in Fig. 3.

The effects of different powers and irradiation times on pyrolysis of MSW are shown in Figure 4. It was observed that the amount of energy input and temperature intensity for pyrolysis of MSW were realized at these higher power inputs. At the 600-850 W of the power input, the energy required to drive the reaction was determined very fast and the necessary pyrolysis was started within the short period of irradiated time. The pyrolysis of MSW was subjected to different power inputs and irradiated times. The results show that the pyrolysis of MSW would take place only at a higher power input.

Table 1 *Percentage of composition of different fraction in MSW [3].*

Sample no.	Component of MSW	% Composition (Approx.)
1	Paper	7-10
2	Plastics	0.87-0.96
3	Metals	0.4-0.8
4	Glass	0.39-0.86
5	Organic matter	35.4-43.7
6	Inert	28.7-39

Table 2 *Proximate Analysis of MSW [3]*

Sample	Moisture Content (wt%)	Volatile Content (wt%)	Ash Content (wt%)	Fixed Carbon (wt%)
MSW	4.6379	77.94	5.32	16.73

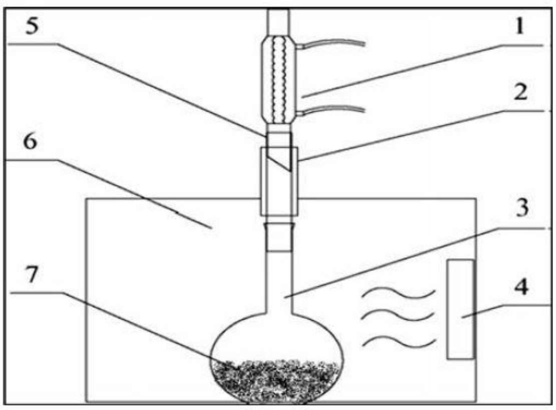

Fig. 3 *The electromagnetic-assisted reactor, (1) water-cooled condenser, (2) mercury seal, (3) round bottom flask, (4) magnetron, (5) glass tube, (6) cavity, and (7) MSW sample in sample holder [3].*

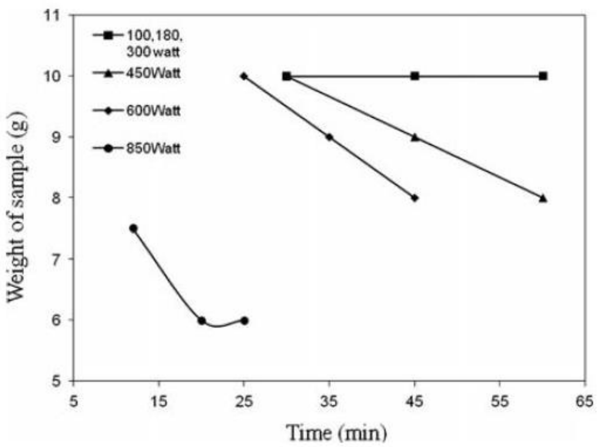

Fig. 4 *Effect of power on pyrolysis of MSW [3].*

Table 3 *Content of major elements in the waste material of electromagnetic pyrolysis [10]*

Element	C	H	N	O	others
% of mass	37.2	6.68	1.24	26.63	28.25

5.2 Electromagnetic Pyrolysis of MSW

In [10], technology for electromagnetic pyrolysis of MSW was studied. The content of major elements in the waste material of electromagnetic pyrolysis was shown in Table 3.

The changes of heating rate of the material in cavity were investigated. The temperature of waste material increased quickly and it decomposed at lower temperature, for the characteristic and mechanism of electromagnetic heating is different from the traditional mode of heating. The results of various temperatures of pretreatment waste in electromagnetic were shown in Figure 5. Temperature reduced obviously at 350°C during the pyrolysis of wastes. It occurs that waste pyrolysis at 350°C is an endothermic process and needs the electromagnetic radiation energy for the acceleration of pyrolysis rate.

For the energy consumption analysis, the relationship between temperature in cavity and total power consumption are shown in Figure 6. From ambient temperature to 350°C, material temperature rapidly rises up and power consumption is less, because less material decomposes. It is the temperature-rise period of waste material. After 350°C, the power consumption increases and the rate of temperature-rise slow down, because it provides energy for both temperature-rise period and pyrolysis process.

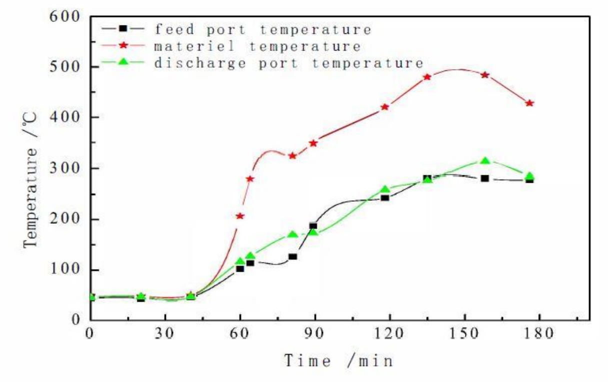

Fig. 5 *Changes of furnace temperature in the electromagnetic pyrolysis process [10].*

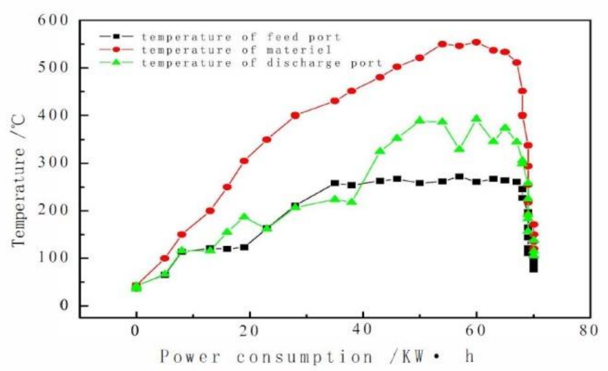

Fig. 6 *Temperature in cavity and energy consumption [10]*

6. CONCLUSION

In this paper, pyrolysis technologies based on dielectric heating were discussed in the various topics concerning about MSW. While referring to dielectric heating systems were related to rapid process control and selective heating.

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