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Review of Typical Municipal Solid Waste Disposal Status and Energy Technology

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Abstract

The physical and chemical components of urban domestic waste, medical waste and electronic waste are introduced, the advantages and disadvantages of the existing processing methods are pointed out. Considering the higher content of organic and metal of these municipal solid wastes, pyrolysis technology is a suitable method to make them harmless, reduced, reusable and being available energy.

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Keywords: Municipal solid waste; Pyrolysis technology; Energy conversion

1. Introduction

With the rapid development of social economy, the number of municipal solid waste increases rapidly. According to the "*2014 National Large and Medium Cities Solid Waste Pollution Prevention and Environmental Control Annual Report* ", 261 large and medium cities of China produced about 161.48 million tons domestic waste, 0.54 million tons medical waste, and 39.87 million electronic waste in 2013[1]. How to deal with and recycle these solid wastes properly has become a hot research point. The status and treatment technology of municipal solid waste in China has been discussed, the feasibility of PPP model applied to the treatment of municipal solid waste, and the influence factors and suppression methods of PCDD/PCDF composition process have been analyzed [2-5]. The synthesis of dioxin in municipal solid waste incineration process was investigated experimentally, the principle of pyrolysis and gasification of medical waste has been studied [6-10]. Moreover, the new method of treating medical wastes by pyrolysis and incineration was put forward. Characteristics of pyrolysis and main influencing factors were studied experimentally, and the optimum heating rate, final temperature and heat preservation time were determined. Electronic waste contains not only a large number of decomposable organic matters, but also a lot of recyclable metal and non-metallic materials, it can be converted into

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resource and energy. The present situation of electronic waste treatment technology was introduced, and the technology and equipment for pyrolizing waste cable and motor windings have been studied[11,12]. H.T. Ma et al.[13,14] investigated the thermogravimetric characteristics and pyrolysis kinetic model of typical printed circuit board, and the optimum separation parameters have been obtained.

2. Processing Status And Problems

2.1. Urban Domestic Waste

About 178.99 million tons urban domestic waste were produced in China by the end of 2014. The main components included organic matter (mainly from kitchen waste), flammable organic matter (plastics, waste paper, rubber, leather, bamboo, cloth and so on) and inorganic matter (coal cinder, bricks, ground ash, glass, metal and so on).

In the urban domestic waste, the rotting organic matter accounts for more than 50%, the flammable organic takes from 20% to 40%, the proportion of inorganic matter is less than 20%, moisture content of that ranges from 40% to 60%, and the low calorific value varies from 4000kJ/kg to 6000 kJ/kg.

At present, the main waste disposal methods include sanitary landfill, composting and incineration, etc. Among them, the sanitary landfill is the most popular method, accounts for 77% in 2010, but will decrease to 55% by 2015.

Sanitary landfill technology is mature and cheap, but it will occupy plenty of land resource, and might cause the secondary pollution to soil and underground water. As a result, this method has been limited gradually.

Composting method has advantages of simpler in technology, low investment, simple operation, low running costs. It is the earliest and popular method to treat the urban domestic waste. With the increase of organics in the urban domestic waste, the quality of compost has been improved significantly.

However, because of the lack of effective way to sort and collect urban waste, some glass, plastic, batteries, kitchen and other organic waste are mixed together. Moreover, in the open-field static composting process, the stench and agglomeration of mosquitoes can not be controlled and will pollute the environment, the ratio of composting is less than 10%.

Compared with sanitary landfill, incineration has advantages of occupying small area, handling in short time, reducing significantly (weight loss up to 70% and volume reduction up to 90% of original waste) and high degree of harmless. In addition, in the process of burning, the resulting heat can be recycled and utilized. It has been widely used in developed countries. For example, 16% in America, 75% in Japan, 40%-50% in German and France, 9%-10% in Britain and 5%—6% in Canada.

In China, incineration treatment method is becoming more and more popular, according to the 12th five-year plan about the domestic waste, there will be more than 300 domestic waste incineration power plants being built by 2015. The amount of domestic waste treated by incineration will increase from 90000t/d to 307000t/d from 2010 to 2015, taking 35% of the total amount, and more than 60 billion RMB investment is needed. It is estimated that the operating income by garbage incineration power generation will increase to 18.9 billion RMB by 2020. Taking into account the government subsidies(80 RMB / ton), the total operating income would reach 150 billion yuan during the 12 Five-Year Plan and 13 Five-Year Plan.

However, incineration treatment method has shortcomings of high investment, low calorific value, lack of reliable and practical technologies, excessive toxic and hazardous substances（PCDDs/PCDFs) in the exhaust gas. As a result, its application has caused people's worries.

2.2. Medical Waste

It is reported that about 700 thousand tons of medical wastes are produced in China ever year. The typical physical parameters of medical waste are shown in table 1.

Table1 The typical physical parameters of medical waste

Parameter	Min	Max	Avg
Combustible Component Content	83%	99%	
Minim Combustion Value	12550kJ/kg	25100kJ/kg	
Humidity Ratio	0 (Plastic Waste)	90% (Pathological Waste)	35%

In most countries, medical waste is considered as "Top dangerous" and "Fatal Killer". It might contain infectious bacteria, virus, chemical pollutants and radioactive harmful substances, etc, some strict rules on medical waste treatment has been made to manage it.

The existing processing methods include incineration, steam sterilization, chemical disinfection, electromagnetic wave sterilization, sanitary landfill and so on.

The incineration method has advantages of sterilizing thoroughly, reducing significantly, wide application and technical maturity. However, in the incineration process, organic matter will be decomposed to form dioxins and chloride, this will cause secondary pollution.

Steam sterilization is an effective sterilization method with advantages of sterilizing thoroughly and quickly, operating easily, but this method is not suitable for treating pathological waste. Besides, it will produce toxic volatile organic compounds and toxic waste water during the process, which will cause secondary pollution. And it has no effect on reducing the volume and weight of medical wastes, the treated medical waste is still required to be buried or burned.

Chemical disinfection method is suitable for treating pathological waste, but the waste need to be sorted and broken before treated. Furthermore, the disinfection liquid is harm to the human body, and the waste gas and liquid, produced during the treatment process, will increase occupational hazard to the operator.

Electromagnetic sterilization could kill the pathogens in medical waste with high sterilization efficiency, and the treatment process does not produce dioxin, but the construction and operation cost is higher, and there is little effect on the reduction of waste.

Sanitary landfill is the terminal method for the treatment of medical waste, all the residue, generated by other methods, need to be centralized landfill. However, the medical waste landfill system has a higher demand for the anti-seepage measures. If there is no anti-seepage measure, all kinds of toxic substances, pathogens and radioactive substances would infiltrate into the soil with the rainwater and cause harm to human health along with the food chain.

2.3. Electronic Waste

Every year, almost 5 million televisions, 4 million refrigerators, 5 million computers, 15.2 million washing machines and approximately 100 million mobile phones should been scrapped, about 1.11 million ton electronic wastes are produced, and having a 20% increase. The main components of electronic waste are shown in table 2.

Table 2 Main components of electronic waste

Equipment	Ferrous Metal %	Non-Ferrous Metal %	Plastic %	Glass %	Circuit %	Board	Others %
PC	32	3	22	15	23		5
Phone	＜1	4	69		11		16
TV	10	4	10	41	7		8
Washer	51	4	15		＜1		30

Due to the characteristics of high value, high harmfulness and difficult to handle, the electronic waste has important economic value and environmental protection significance as being treated harmlessly and circularly.

For the electronic waste, the most used methods are mechanical and physical method, chemical metallurgy, supercutical fluid method and so on.

As the most widely used method, mechanical and physical method has advantages of relative mature technologies, little environmental pollution and high degree of automation. However, there will be large amount pyrolysis gas generated in the breaking process, and this will cause environmental pollution and a decreases of valuable metal recovery rate. In addition, some wasted wire cannot be recycled with mechanical and physical method because of their too small diameters.

Although the pyrometallurgy technology is relatively mutual, harmful gas would be produced due to the thermal decomposition of organic, part of metal would be ablated and oxidized during the incineration process, which will cause a decrease of recovery rate and purity. So the pyrometallurgy has been gradually eliminated.

Hydrometallurgical processing technology is relatively complex, and there will be plenty of acid waste liquid produced during the process, the used nitric acid and aqua regia have a strong corrosive, harmful to environment, and the organic materials in electronic waste cannot be recycled.

3. Application of Pyrolysis Technology in Municipal Solid Waste Energy Regeneration

Pyrolysis process is a technology that converts the high molecular polymer into low molecular compound by direct or indirect heating in condition of anoxybiotic or anoxic. The pyrolysis process can be expressed as follows:

Organic solid waste $\xrightarrow{\triangle}$ Gas (H2, CH4, CO, CO2) + Organic Liquid (organic, aromatic hydrocarbon, tar) + Carbon Black + Slag.

Compared with traditional treatment methods, pyrolysis technology has the following significant advantages:

1) The organic compound in municipal solid waste would be decomposed into oil, gas and solid products. The oil and gas could be used as energy for the pyrolysis process or chemical raw materials. The metallic and non-metallic materials in the solid products can be separated and reused.

2) The pyrolysis process is carried out at a low temperature (300-500˚C), which could prevent metal oxidation and erosion. Meanwhile, the solid waste needn't to be crushed into small pieces. Therefore, the recovery rate and purity of metal are close to 100%.

3) Under anoxybiotic or anoxic conditions, pyrolysis could prevent the formation of dioxins, furans and other harmful substances. The formation of reducing coke will inhibit the generation of metallic oxides and halides. There is no risk of causing re-pollution to the environment.

4) The mass and volume of solid waste can be reduced greatly by using the pyrolysis treatment

methods, which is similar to incineration.

All in all, because of the advantages of harmless, diminishable, resourceable and being energy, pyrolysis technology is the most promising method for treating municipal solid waste.

4. Conclusions

(1) Because of the higher content of organic matter and calorific value, it is suitable for urban domestic waste and medical waste to be decomposed into gas and liquid products that can be used as fuel by using pyrolysis technology.

(2) Electronic waste contains lots of organic matter and valuable metals and non-metallic. By pyrolysis, the metals and non-metallic can be separated and recycled, the organic matter can be used as fuel by decomposing into gas and liquid products.

(3) The pyrolysis process is carried out at a low temperature, so the recovery rate and purity of metal are higher, and the risk of causing re-pollution to the environment could be avoided.

(4) In order to improve the effect of pyrolysis process, it is suggested that the urban domestic waste and medical waste should be classified and dehydrated before being pyrolyzed.

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References

[1] Ministry of Environmental Protection of the People's Republic of China. 2014 national large and medium cities solid waste pollution prevention and environmental control annual report [J]. China Environmental Protection Industry, 2015.01

[2] WANG Ailian, LI Shaodong. Research on the present situation and treatment technology of municipal solid waste in China. Journal of Xi'an Shiyou University (Social Science Edition), 2012, 21:58-63.

[3] Han Shuaiqi, Li Mingzhen, Yang Tiantian. The Application of PPP Model in Urban Domestic Treatment [J]. Environmental Science and Management,2015,4:1-4.

[4] MA Hongting, ZHANG Yufeng. Influence factors and control means of de novo synthesis of PCDF/F. Chemical Industry and Engineering Progress,2006,5:557-562.

[5] Ma H. Synthesized inhibitors of PCDD/Fs when municipal solid wastes incinerated [J]. Journal of Huazhong University of Science & Technology, 2013, 41(2):120-123.

[6] CHEN Jing, ZHANG Yufeng, DENG Na, et.al. Principle of Pyrolysis and Gasification of Medical Wastes [J]. Gas & Heat, 2005,11,71-74.

[7] LI Xinguo, ZHOU Xin, ZHANG Yufeng. Pyrolytic Incineration Treatment of Hospital Wastes [J]. Gas & Heat,2004,9,71-74.

[8] MA Hongting. Experimental Study on the Pyrolysis Characteristics of Medical Wastes [D]. Tianjin University.2007.

[9] MA Hongting, WANG Fangchao, YANG Guoli. Differential thermal analysis during the thermal decomposition of three typical medical wastes [J]. Chemical Industry and Engineering Progress. 2012,31(4):933-937.

[10] MA Hong-ting, ZHANG Yu-feng, DENG Na, et.al. Effect of Heating Rate on Thermal Decomposition Mechanism of

Medical Waste [J]. Research of Environmental Sciences, 2008,5:190-194.

[11] Wu Zhengsheng. Research of Pyrolysis Technology and Equipment for Recycling Waste Cables and Motors [D]. Tianjin University.2012.

[12] CHEN Chen; LI Xiaopeng. Review on the technology of recycling copper resource of waste cable[J]. Recyclable Resources and Circular Economy. 2015,8(1):19-23.

[13] MA Hong-ting, WANG Ming-hui, WANG Fang-chao, et.al. Thermogravimetric Characteristics and Kinetic Models of Printed Circuit Boards from Typical Waste Life Electro-Equipments [J]. Journal of Tianjin University. 2011,44,7:602-606.

[14] Ma Hongting, Sun Jinglong, Du Dan Zhang. Study on optimal separation parameters in waste printed circuit board [J],Chinese Journal of Environmental Engineering. 2010,4(9):2099-2104.

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Research directions:

1) Heat and mass transfer enhancement mechanism and technology research;

2) Solid waste resource recovery technology research;

3) Industrial waste heat recovery and cascade utilization technology research;

4) Building energy consumption analysis and building energy saving technology research.