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Application of best available technologies on medical wastes disposal/treatment in China (with case study)

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Abstract

Medical waste is one special kind of hazardous wastes. If mishandled, it could cause disease spread and secondary pollution of dioxin. China produced huge amount medical wastes due to large population. Through a decade, medical waste centralized disposal sector rapidly developed with both incineration and non-incineration technology. With fully consideration advanced foreign technology, a set of Best Available Technology system of China gradually formed suitable for Chinese national conditions. This article placed emphasis on best available technology system of medical wastes centralized incineration facilities, and analyzed the application of technique retrofit of medical wastes centralized incineration facilities incorporated with case study.

Keywords: Medical Wastes; BAT/BEP; disposal; dioxins; incinerator;

1. Introduction

Medical waste, which contains a mass of virus, bacteria and chemical agent, is listed No.1 Hazardous Wastes at "National Hazardous Wastes List". The net amount of MW produced in China was approximately 670,000 tonnes in 2006, with a daily average output of 1,780 tonnes. Medical waste carries various pathogens, which could cause environmental pollution to water, air and soil and spread disease to endanger human health. If it was mishandled, the release of dioxin, heavy metals and other pollutants from disposal process could case secondary pollution to damage ecological environment. Medical waste has been listed at *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes*

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and Their Disposal and also concerned by *Stockholm Convention on Persistent Organic Pollutants*(hereinafter refer as 'Convention') [1-2]。

There are two major medical waste disposal technologies--incineration and non-incineration technologies. Incineration technology refers to the warm disposal technology and high-temperature thermal disposal technologies. Non-incineration technology refers to the low temperature heat treatment, chemical processing technology, radiation processing technology, biological treatment technologies, and etc [3]. Before the outburst of SARS in 2003, the medical waste in China was managed and disposed in a decentralized way within hospitals. Medical waste was only simply incinerated in incinerators without necessary air pollution control devices, or mixed with municipal solid wastes and then landfill, or illegally reused and recycled. Following SARS epidemic in 2003, Chinese Government moved quickly to establish the National Plan for Construction of Facilities for Disposal of Hazardous Waste and Medical Waste, in which China is committed to construct about 300 dedicated MW disposal facilities across the country. The national survey on hazardous waste and MW disposal facilities found that there are 149 dedicated MW treatment facilities at 2004, which mainly used incineration disposal technology and only 2 facilities was used non-incineration technology. However, the operation of most of incineration facilities was not very successful and it is very difficult to change this situation. With the country ratified Convention at 2004, more and more attention was paid to dioxin release from medical waste incineration. The non-incineration technology of medical waste disposal was rapid developed within the country. Up to the end of 2010, there are more than 200 medical waste disposal facilities approved, constructed and operated within National Plan for Construction of Facilities for Disposal of Hazardous. The applied technologies were included pyrolysis incineration, rotary kiln incineration, autoclave, chemistry disinfection, and microwave and its combination of technology. The distribution of incineration technology and non-incineration technology in these facilities was around 50% each [4].

Nomenclature

BAT	Best Available Technology
BEP	Best Environmental Practice
MW	Medical Waste
SARS	Severe Acute Respiratory Syndrome
UNEP	United Nations Environment Programme

2. BAT of MW disposal/treatment

2.1. Concept of BAT/BEP

Medical waste incineration was listed as high formation and release of dioxin source by Convention. In order to reduce the dioxin release from industrial sources, UNEP has developed BAT/BEP guideline. "Best available techniques" means the activities and it operation has reached most applicable effective and advanced stage, thus this specific technique by principle has practical sustainability to reduce POPs pollutants. "Best" means most effective in achieving a high general level of total protection to the entire environment. "Available" means those techniques that are accessible to operators and that are developed on a scale that allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages. "Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned. "Best environmental practices" means the application of the most appropriate combination of environmental control measures and strategies. [2,5]。

According to Article 5 of Convention, each party shall promete the application of BAT/BEP mearues in a time manner . The BAT/BEP guidelines systemicly illustrated different incineration techniques, has listed the process design and operating parameters to rotary kilin, pyrolysis, fluidized bed, and etc incinerators, and also give related requirements of medical waste process of generation, collection, segragation, storage, tranportation, treatment and final disposal. In addition, BAT/BEP guildlines illustrated the alternative technologies of medical waste treatment, such as autoclave, micorwave and so on, and suggested priortize alternative technology when build a new disposal facility. [2]。

2.2. Principles of BAT selection

Considering the selection standard of medical wastes disposal technologies of international convention and international organizations, combining with the domestic actual situation, the following factors should be considered for a technique selection [6,7,11]：

- "Environmental desirability" means the adopted waste disposal technique and management ability could insure public health and environmental safety.
- "Administrative diligence" means related management ability could insure adopted policies and measures could realize and be long term effective, especially for environmental impact.
- "Economic effectiveness" means the adopted disposal techniques and management measures are cost effective and considering the cost of waste disposal.
- "Social acceptability and equity" means the adopted disposal techniques and management measures could be supported and accepted by local society, including the efficiency of waste management measures.

Because of above consideration, the major factors of selection of medical wastes disposal technologies were listed at table 1.

Table 1 the major factors of selection of medical wastes disposal technologies

No.	Considering category	No.	Choice indicator	Key factors
A	Environmental desirability	A1	Disposal scale suitability	the adaptability of the local planning scale
		A2	Disposal effectiveness	local facilities matching ability
		A3	Disposal of waste applicability	Complementarity between local waste type and supporting facilities
		A4	System configuration completeness	Correspond with standards and specifications
		A5	Unit design sophistication	Correspond with standards and specifications
		A6	Automation control level	Correspond with standards and specifications, Automation advanced
		A7	The safety of disposal facilities	Facility safety protection measures dispositions level
		A8	Supporting infrastructure needs	The degree of difficulty of Supporting facilities
		A9	Energy-saving performance situation	Energy saving effect of comparative advantage
		A10	Disposal facilities practicality	The complexity of the facilities and operability
		A11	Supervision means reliability	The corresponding local supervision and monitoring ability
B	Administrative diligence	B1	Risk of producing poisonous and harmful pollutants	Produce poisonous and harmful pollutants risk
		B2	Risk of secondary pollution	Consider waste gas, waste water and waste residue, noise and other environmental factor
		B3	Risk of occupational health and safety	Considering technical application on operating personnel health risks
		B4	Environmental impact risk of the surrounding residents	Pollutants release impact to surrounding residents
		B5	Ecological environmental impact risk	Pollutants release impact to ecological environment
C	Economic effectiveness	C1	construction cost	Consider main equipment and ancillary facilities cost
		C2	operating cost	Consider waste disposal cost and equipment depreciation
		C3	income level	Consider profit level and operation sustainable ability
D	Social acceptability and equity	D1	The public acceptability	Comprehensive evaluation on pollution level and the public reaction
		D2	Policy allows	Evaluation from policy perspective of technology application
		D3	The difficulty of location selection	Evaluation from health and safety distance angle
		D4	The difficulty of technology acquisition	Evaluation from difficulty of technology acquisition

2.3. Incineration technology optimization concept

Currently air control type incinerator is the most widely used incinerator type aboard[8]。Medical wastes incineration facility usually contains waste feeding system, incinerator, flue gas purification system, slag treatment system, and etc. Different techniques could be used to different systems, and then medical wastes disposal technologies present various combinations of different systems. The hardware structure and pollutant control measures of medical waste disposal facilities were listed at Figure 1.

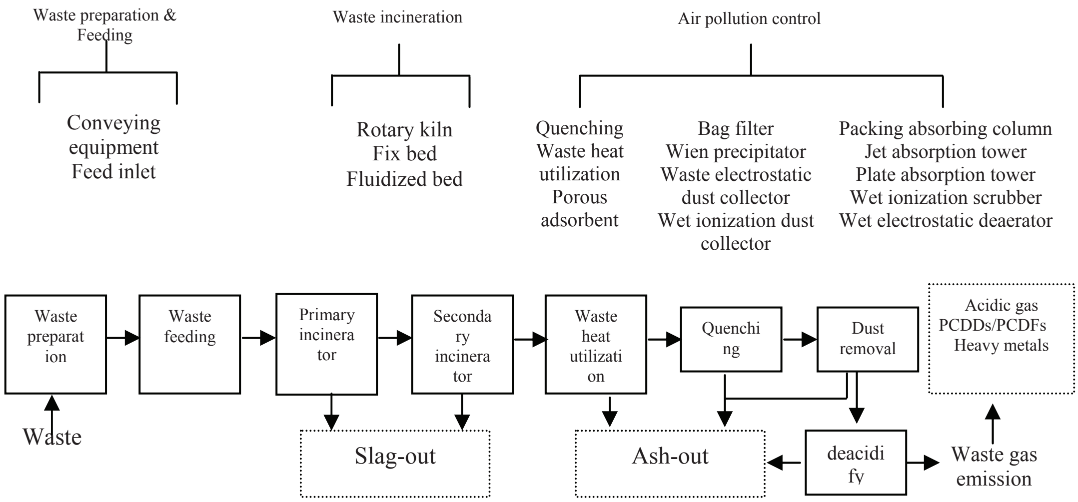

Figure 1. The hardware structure and pollutant control measures of medical waste disposal facilities

From Figure 1, it is clear to see one incineration disposal facility could has various unit design and system dispositions. To insure one incineration disposal facility reach the requirement of BAT/BEP, it need consider the entire incineration system structure characteristics. Medical waste incineration disposal best available techniques combination is illustrated at Figure 2. [6,9]。

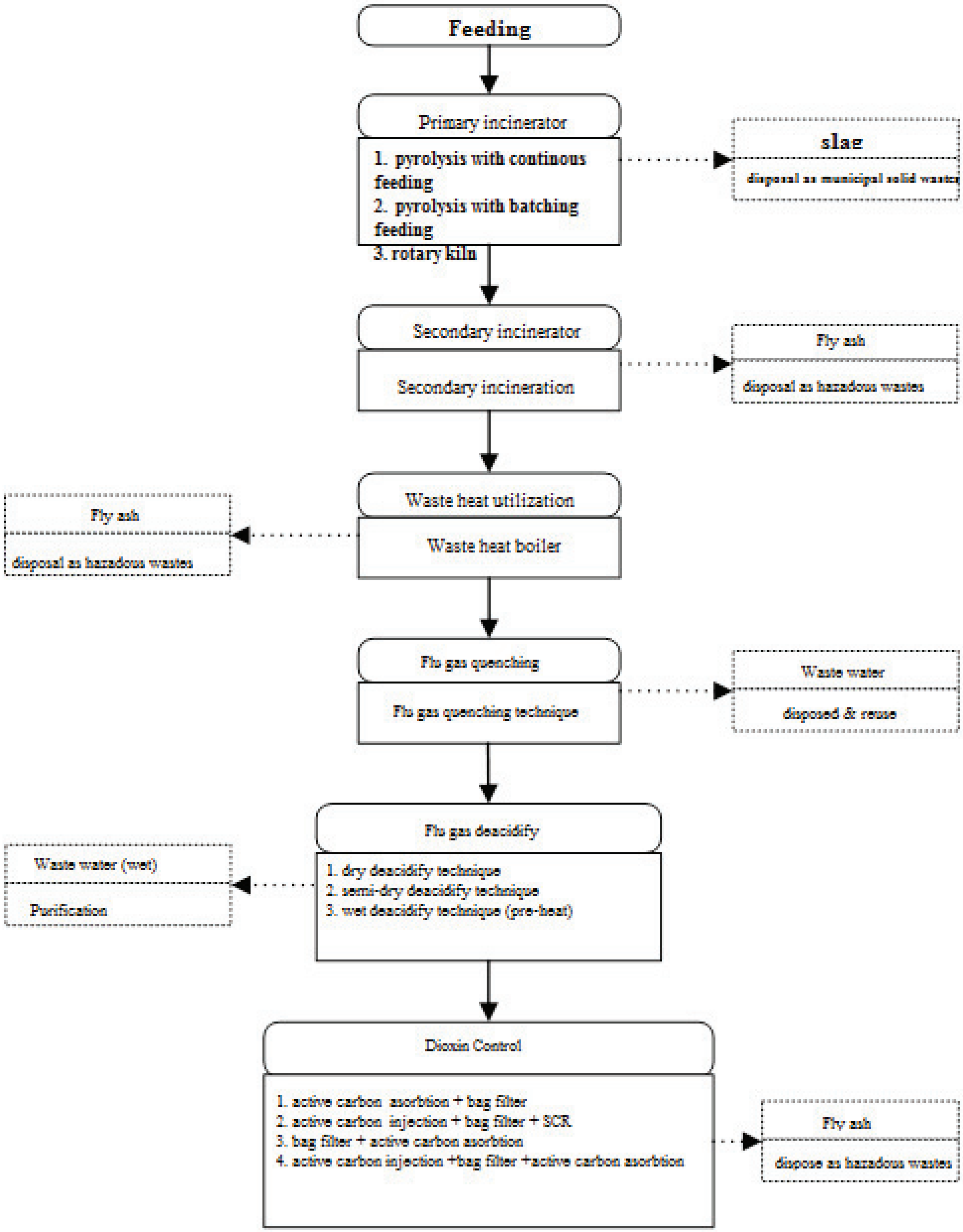

Figure 2. Medical waste incineration disposal best available techniques combination

Best available technique parameters

- For pyrolysis incineration technology, temperature of primary incinerator is 600～800℃ ; For rotary kiln incineration technology, temperature of primary incinerator is 600～900℃.
- The temperature of secondary incinerator is no less than 850℃(chemical and pharmaceutical wastes is no less than 1100℃); Flu gas residence time is no less than 2s.
- Combustion efficiency of medical waste incineration facility is no less than 99.9%.
- Internal pressure difference of initial stage of combustion of secondary incinerator is about -10mmH_2O，Internal pressure difference of Spontaneous combustion period is about -12mmH_2O。
- High temperature flu gas enters waste heat utilization device, and the temperature of flu gas at exit falls to 600℃.
- The recovered heat could use for bag filter, life heating, and etc.
- The flu gas exits from waste heat utilization device should apply quenching system to cool the flu gas under 200℃ within 1s and reduce the retain time of flu gas at 200～500℃ temperature zone.

On the basis of adoption BAT, the dioxin release could be lower 0.1ngTEQ/Nm3 and the acid gas, heavy metals, and other pollutants could reach related pollution control requirements. Waste water could reach disinfection and purification requirements. Rate of heat loss on ignition of incineration slag is lower than 5%. The waste water after treatment could discharge or reuse. Incineration slag disposes as municipal solid wastes. Fly ash disposes as hazardous wastes [6] .

3. Case study

3.1. Case 1:BAT demonstration retrofit technique of Pyrolysis incineration with continuous feeding system

3.1.1 Basic situation

The construction scale of demonstration project is 15tons per day. The major incineration system is vertical continuous pyrolytic incineration system with semi-dry flu gas purification, active carbon injection and bag filters. The entire process is feeding— primary incinerator— secondary incinerator— waste heat boiler – quenching tower—deacidity tower— active carbon injection — bag filters. After high temperature flu gas enter waste heat boiler, temperature was dropped from 1200℃ to 600℃ and produced 0.98 MPa steam. The steam could use for bag filter, room heating, bath water and so on. The 600℃ flu gas entering quenching tower, atomized cold water cooled the flu gas to 200℃ within 1s. And then the flu gas entered deacidity tower，atomized NaOH solution will neutralize acid pollutants in flu gas. The active carbon injection with spiral plate feeder was ahead of bag filter. The active carbon was added to spiral plate and negative pressure of flu gas tunnel could suck the active carbon. Dioxin, heavy metal, smoke dust and other pollutants was absorbed and removed within bag filter. Purified flu gas was released through 35 meters stack.

3.1.2 Major retrofit techniques

a) Retrofit auto control system of major equipment. Add new meter for pyrolysis incinerator, enhance control to adjust to great change of medical wastes heat value. Retrofit auto control meter of quenching tower to adapt great change of flu gas and prevent over spray or less spray. Add new meter for deacidity tower to realize the dynamic control with flu gas flow, flu gas temperature, acid gas concentration and insure the deacidify result.

b) Change bags of bag filter. Use Acid and alkali resistant new coated filter material and utilize waste boiler to heat bag filter. Maintain the temperature inside bag filter higher than dew-point temperature of flu gas20℃～30℃. Amplify the pressure of pulse injection and use online ask removal method to extend the lifetime of filter.

c) Add refractory material to flue. Add refractory material to flue and stack to reduce the corrosion within the system and extend the lifetime of the flue and stack.

d) Add one Selective Catalytic Reduction (SCR) tower. To reach dioxin release limit to 0.1TEQng/Nm3， the demonstration project chose SCR tower to decompose dioxin in flu gas to CO2 and H2O using catalytic decompose technique.

3.2. Case 2:BAT demonstration retrofit technique of Pyrolysis incineration with in batching feeding system

3.2.1Basic situation

The construction scale of demonstration project is 5tons per day. The major system is consist of feeding— pyrolytic incinerator— secondary incinerator—air water heat exchanger—quenching & deacidity tower— active carbon injection — bag filters— stack. The flue gas exited from secondary incinerator and entered air water heat exchanger, the temperature cools to 600℃. The flue gas entered semi-dry spray deacidity tower, adequately mixed with the alkaline solution, and the temperature dropped to 200℃ suddenly. Active carbon mixed with flue gas to absorb the dioxin and heavy metals. Finally flue gas will purify within the bag filter and release through stack to ambient air. After pyrolysis gasification, the slag through high temperature oxygen enrichment ashing, rest combustion flu gas complete combustion at pyrolytic incinerator and secondary incinerator. The pyrolytic incinerator change to Rich oxygen burning furnace (the melting furnace) with temperature more than 1100℃ and insure the rate of heat loss on ignition of incineration slag is lower than 3%.

3.2.2 Major retrofit techniques

a) Perfect feeding system. Perfect feeding system to adjust to solid, semi-solid and liquid, compile operation standard of medical waste feeding to improve the stability of chemical composition and energy of different batch.

b) Improve and enhance meter of pyrolytic incinerator and control level. Efficiently regulate and control the rate and efficiency of drying, pyrolytic, gasification and ashing. One hand it will shorten dispose time of each batch medical wastes, reduce labor intensity and improve handle ability of equipment. On the other hand, it could control the rate of gasification and composition of pyrolytic gas, enhance relative stability of flu gas to secondary inlet, and reduce the using of subsidiary fuel and the wave of exit temperature.

c) Improve active carbon injection device. Improve the performance of active carbon injection device, extent the absorb time of mixed active carbon and flu gas to bag filter, and enhance the efficiency and rate of active carbon absorb dioxin and heavy metal.

d) Improve the dedust efficiency of bag filter. Realize flu gas zero leakage from bypass tunnel and insure the bag filter exit dust release concentration lower to 30mg/Nm3 .

e) Use Selective non-catalytic reduction- selective catalytic reduction (SNCR-SCR) system to remove nitrate and decompose dioxin, make sure dioxin release lower than 0.1 ngTEQ/Nm3 [10].

4. Conclusion

During eleventh-five year period, a batch of medical waste centralized disposal facilities was built and operated at locally administrated level of China. However, the total operation situation is not optimized. The problem such as failure to continuous operation, system corrosion, high energy consumption, frequent equipment instrument damage, bad automatic control system performance, and on-line monitoring system failing to normal running, were exposed. Reaching dioxin emission standard situation is not optimistic. The urgency of dioxin control of incineration system has become increasingly prominent. *Guidance on Strengthening Dioxins Pollution Prevention and Control* clearly pointed out the dioxin release reduction of prioritized sector will be 10%. *Guidance on Strengthening Dioxins Pollution Prevention and Control for Medical Waste Disposal* was issued at end of 2011. Hazardous waste incineration pollution control standard is under revising. It is planned to adjust dioxin release concentration from 0.5 $ngTEQ/Nm^3$ to 0.1$ngTEQ/Nm^3$. The exiting medical waste incineration disposal facility is facing the urgent need of retrofitting and optimizing.

Acknowledgements

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