Study on the Problem of Pollutant Emissions From Incineration and the Prevention and Control of Such Emissions

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Abstract. As the world's demand for energy increases, incineration for power generation is becoming a mainstream option as an effective method of waste treatment and energy production. However, pollutants from incineration for power generation become a challenge for environmental sustainability. Therefore, this paper aims to explore the pollutants generated during power generation incineration and to analyse specific countermeasures. This is essential to alleviate pollution mitigation and ensure human health. This paper concludes that, incineration power generation, as an important waste treatment and energy production method, the treatment of its pollutants is an issue relevant person must pay attention to. Adopting advanced treatment technologies, such as fluidised bed technology, can effectively reduce the emission of pollutants and protect the environment and human health. At the same time, researchers must continue to explore and research new types of pollutant treatment technologies to provide strong support for sustainable development in the future. The research in this paper allows for the improvement and enhancement of incineration technology to make it sustainable.

Keywords: Incineration technology; contamination; sustainability.

1. Introduction

First of all, the acceleration of urbanization has brought a lot of domestic waste, the traditional landfill has been unable to meet the treatment needs, and easily causes environmental pollution. Therefore, incineration power generation, as a harmless, reduced and resource treatment method, began to be favored. Through the high-temperature incineration technology, municipal solid waste can be decomposed quickly, and the heat in the garbage can be converted into electric energy to realize the reuse of energy. Secondly, with the improvement of environmental awareness and the development of technology, people pay more and more attention to waste incineration power generation. People begin to realize that garbage is not worthless "waste", but contains rich energy resources. At the same time, with the progress of technology, the efficiency of municipal solid waste incineration power generation has been significantly improved, such as the use of advanced combustion control technology, flue gas treatment technology and energy recovery technology, which can greatly reduce the impact on the environment and improve energy efficiency [1,2].

However, there are also some problems and challenges in waste incineration power generation. On the one hand, the cost of construction and operation is high, which requires a lot of capital investment and technical support. On the other hand, public acceptance of waste incineration for power generation varies, and some people worry that it may hurt the environment and health. To sum up, waste incineration power generation as a new way of energy utilization, and its background involves many aspects. With the acceleration of urbanization, the improvement of environmental awareness, the development of technology and the support of government policies, waste incineration power generation has gradually become a feasible energy solution. However, there are also some problems and challenges, and there is a need to continuously strengthen technological innovation, regulation and public communication.

This paper discusses the problems associated with incineration and a comparative analysis of the technologies and concludes with some recommendations for combating them.

2. Analysis of Problems Caused by Incineration

The initial municipal solid waste management was born after the Industrial Revolution. During the last quarter of the 19th century, humans found that incinerating and recovering can handle the increasing waste volumes, and then the first batch of incineration plants appeared in US and Europe. Incineration technologies have evolved over decades of progress. From simple open burning, they have evolved into highly efficient incineration power plants. In China, incineration technology was first introduced at the end of the 1980s and the first modernized incineration plant was built in Guangdong province in 1988. To utilize the resources in the waste fully, the Chinese government promotes the construction of a waste classification system, that is more favorable to waste incineration, minimizing the amount of pollutant emissions produced. Generally, garbage can be divided into four categories, recyclables, kitchen waste, harmful waste and other wastes. The recyclables mainly include waste paper, plastic, glass, metal and cloth, which can be reused after recycling and processing. Kitchen waste also named wet waste due to the high moisture content, hurts the calorific value of the fuel. Harmful waste contains heavy metals, and toxic substances and waste do harm to human health or the environment. Except for these three categories, the other wastes mainly refer to bricks, ceramics, paper towels, and others that are hard to recycle.

While the introduction of incineration technology addressed the issue of waste disposal, it also resulted in various forms of pollution.

(1) Hazardous emissions

Domestic waste incineration and power generation projects require a large amount of combustion, which produces harmful gases such as carbon dioxide, carbon monoxide, dioxins, nitrogen oxides, etc., and waste residues, causing serious pollution to the surrounding environment. These gases not only pollute the air but also have serious impacts on human health. For example, carbon monoxide is a toxic gas that can cause a lack of oxygen in the human body, while nitrogen oxides are the main component in the formation of photochemical smog.

(2) Particulate emissions

During the incineration process, a substantial amount of particulate matter is generated, consisting of dust and incompletely burnt material, contributing to air pollution. These particulates not only pollute the air but also damage the human respiratory system. Prolonged exposure to such an environment can lead to lung disease, asthma and other health problems. At the end of the incineration process, some harmful residues are produced, such as slag and fly ash. These residues may contain harmful substances such as heavy metals and dioxins, which pose a threat to the environment and human health. Dioxin, for example, is a highly toxic substance that can persist in the environment for a long time and have serious effects on the human reproductive and immune systems.

(3) Refuse leachate

Waste contains organic substances and heavy metal elements that, if not properly treated will produce toxic and harmful leachate, with heavy metals contaminating groundwater, which will not only pollute the atmosphere and soil but also have a significant impact on the lives and health of the people.

(4) Stink and odour emissions

The incineration process can produce unpleasant odours and smells resulting from the volatilisation and reaction of various hazardous substances. Smells and odors not only affect the quality of life of residents, but can also affect their health.

(5) Noise and vibration

The incineration process generates a lot of noise and vibration, which may affect the surrounding environment and residents. Prolonged exposure to such an environment may adversely affect one's hearing, sleep, etc.

(6) Greenhouse gas emission

The incineration process also produces large quantities of greenhouse gases such as carbon dioxide and methane. The emission of these gases may lead to global warming and aggravate environmental problems.

3. Comparison of Incineration Technologies

Solid waste incinerator combustion methods to illustrate the example of comparative analysis of technology, has been put into operation solid waste incinerator combustion methods are:

Grate furnaces such as multi-stage stepped chain grates, tilting reciprocating grates and Martin grates of the reverse-feed type. Multi-stage ladder grate is composed of reciprocating moving parts, solid waste through the feeder device pushed to the inclined grate on the high-temperature heating in the furnace, so that part of the solid waste can be dried. The other movement of the grate in addition to the solid waste pushed forward, and will be the solid waste layer of loosening and can go through the drying, fuel and afterburning and other stages to achieve complete combustion. At present, in the application of multi-stage ladder type many kinds of grate design mainly belong to the design of the manufacturer's patents, such as China's Shenzhen, the introduction of the new grate, which is a German patent.

Multistage trapezoidal grates have their own advantages, but other types of grates, such as rotary grates and fan-return grates, also have their own challenges. The rotating grate is easily clogged, maintenance is high, the possibility of large objects getting caught in the grate is higher, the moving grate has a large footprint, the duct system is complex, the incineration of high moisture, low value solid waste is still incomplete, it is more difficult to catch fire and it is used in smaller quantities. The reciprocating grate is still in the process of continuous improvement because the combustion is not easy to control and the furnace temperature is high [3].

Martin grates because the domestic has not been able to manufacture their own, must be imported foreign equipment, expensive. General small and medium-sized cities cannot afford its investment cost. The city of Shenzhen, China, is the only place where three Martin furnaces from Japan have been introduced, demonstrating improved performance. However, it is important to note that the combustion conditions of the Martin grates are susceptible to fluctuations in solid waste levels.

Rotary combustion - rotary furnaces; The rotary furnace incineration system is derived from the design of the refractory brick lined rotary kiln that has been widely used in the cement industry. Solid waste is fed into the rotary kiln from the upper front end of the kiln which is tilted and slowly rotating, and the forward speed of the solid waste is controlled by the rotating speed, so that the solid waste is transported forward in the kiln to complete the drying, incineration and ash cooling process, and the cooled ash is discharged from the lower end of the kiln [4].

Rotary kiln combustion adaptability, can burn different properties of the waste this type of furnace’s mechanical parts are relatively small, have less failure, and can be a long-time continuous operation. But the rotary kiln's thermal efficiency is low, such as the need for auxiliary fuel consumption is more, the temperature of the discharged gas is low, there is a bad smell, the need for deodorisation devices or introduced into the high temperature combustion chamber incineration, due to the kiln body is longer, covers an area of large, and the combustion chamber of the grate after the more stringent structural requirements, so it is costly, more expensive.

Municipal solid waste (MSW) incinerators in developed countries have been a relatively mature technology, most of the solid waste incinerated in developed countries in a calorific value of 2000kcal/kg or more. Domestic development and development of municipal solid waste incinerator belongs to the simple incinerators, have not been able to achieve efficient incineration and low-pollution emissions. The introduction of a grate incinerator is expensive, poor economy, difficult to promote the application.

Fluidised bed furnace combustion technology is a new type of clean combustion technology that was rapidly developed in the early 1960s of this centuries. The basic feature of the incinerator using this technology is that the lower part of the furnace chamber is arranged with a temperature-resistant air cloth plate, which is equipped with heat-carrying inert particles, and the inert particles are made to be boiling state through the air cloth under the bed to form a fluidized bed section, and there is a sufficiently high combustion section (i.e., the suspension section) on top of the fluidised bed section.

General material into the fluidised bed, particles and gas between the heat and mass transfer rate is high, the material in the bed is almost completely mixed state, and waste thrown into the bed can

be quickly dispersed evenly. Because the heat carrier stores a large amount of heat, can avoid the rapid change of furnace temperature when feeding, the temperature of the bed to maintain uniform, to avoid local overheating, so the bed temperature is easy to control. At the same time, it has the advantages of high fuel efficiency, wide range of load regulation, low pollutant emissions, high heat intensity, and suitable for combustion of low calorific value fuels. It can be said that China's current solid waste incinerator in small and medium-sized towns has the most promising development prospects for fluidised bed furnace. In particular, China's solid waste calorific value is relatively low, to achieve its efficient and stable combustion, fluidised bed incineration technology is undoubtedly the best choice.

On the other hand,In addition to technology-related differences, the performance of waste treatment systems is highly dependent on geographical factors such as MSW composition, energy mix and related information. MSW characteristics vary considerably from one region to another, e.g. the proportion of paper (newspapers and packaging) is higher in Europe, whereas the proportion of organic components is more important in Asian countries such as China, India and Thailand. Mechanical grate (MG) incinerators dominate the global market. Whereas Fluidised Bed (FB) incinerators are less used in Europe, the proportion of capacity is much higher in Asian countries, especially in China, due to their attractive characteristics for treating high moisture MSW. Therefore, local MSW and operating conditions must also be considered when developing effective WtE practices [5].

4. Pollution Prevention and Control Measures

4.1. Odour Gas Pollution Prevention and Control Measures

Rubbish in the incineration power plant, in the unloading, stacking, and feeding processes easily produced malodorous gases, the main pollution factors include H, S, NH, and others.

Rubbish trucks in the unloading process due to unloading door opening, rubbish spillage and other reasons, will cause the power plant unloading platform to retain part of the rubbish odour, can be unloaded in the power plant platform in and out of the installation of wind screen device, effectively blocking the part of the odour spread.

The rubbish entering the plant must be stored in the rubbish storage warehouse, the rubbish unloading room and the storage warehouse are usually designed as a relatively closed one. To effectively control the spillage of odour from the rubbish storage, the interior of the rubbish storage should be under slightly negative pressure. Usually, a fan suction port is set above the rubbish storage, and the volatile gases in the rubbish storage are sent to the furnace for incineration, so as to ensure the negative pressure requirement of the rubbish storage. At the same time also need to strengthen the operation and management of the rubbish storage warehouse, the use of grabs constantly on the rubbish stirring, and turning, not only can make the furnace into the rubbish calorific value of uniformity, and can avoid anaerobic fermentation of rubbish, reduce the bad smell [1].

4.2. Garbage Leachate Pollution Prevention and Control Measures

To effectively prevent the pollution of soil and groundwater by rubbish leachate, the bottom and the surrounding area of the rubbish storage and leachate collection pool should have good impermeability. Asphalt concrete with an impermeability coefficient of 1x10- cm/s or HDPE with an impermeability coefficient of 1x10 "cm/s can be used for seepage control [1].

At the bottom of the rubbish storage should also be set up filtration layer, rubbish storage side of the infusion trench, the bottom of the rubbish storage slope to the infusion trench, rubbish silo leachate and unloading platform rinse water and flow into the leachate collection pool.

Rubbish leachate has the characteristics of complex composition and high concentration of pollutants. If the fluidised bed incinerator is used, it can be pumped to the furnace chamber for high-temperature oxidative decomposition treatment; grate furnace can be used anaerobic reactor pretreatment , membrane biochemical reactor biochemical treatment and nanofiltration treatment

process, to be treated to meet the water quality standards for reuse of reuse water, reuse of all as plant industrial supplementary water, etc.; or pre-treated to meet the standards for taking over the wastewater treatment plant by the wastewater treatment plant treatment.

The leachate collection tank should be set up with sufficient capacity according to the storage time of rubbish under the accident condition; the sludge or concentrate produced in the process of leachate treatment should be incinerated in the plant itself, and should not be transported out for disposal [1].

4.3. Pollution Control Measures for Gaseous Dioxin

(1) Pre-treatment of waste before combustion. Chlorine is a necessary substance for the generation of dioxin, and heavy metals play a catalyst role in the generation of dioxin. Therefore, before waste incineration, pre-combustion pretreatment should be carried out to sort out plastics and waste tyres from the rubbish and adopt degradation or pyrolysis method to treat them and reduce the content of organochlorine in the rubbish, so as to control the generation of dioxin-like substances in the process of rubbish incineration from the source.

(2) Improve combustion conditions. As dioxin can be completely decomposed in 0.21s under a high temperature above 800℃, it is necessary to maintain the high temperature in the furnace, prolong the residence time of the gas in the high temperature area, strengthen the turbulence in the furnace, promote the diffusion of air, mixing, and as far as possible, make the rubbish in the furnace to be completely combusted.

(3) flue gas sprayed into a certain amount of NH, Ammonia is sprayed in front of the boiler tube bundle, on the one hand, the binding ability of ammonia and chlorine is stronger than that of dioxin precursor and chlorine, which reduces the dioxin generated from the combination of precursor and chlorine; on the other hand, Cu and other heavy metals in the fly ash are the catalysts for the synthesis of dioxin by the precursors, and play a decisive role in the synthesis of precursor, and ammonia is the most effective poisonous substance to the catalysts for heavy metals such as Cu, and it can make Cu and other heavy metal catalysts lose their catalytic effect, thus reducing the amount of dioxin. Ammonia is the most effective toxicant for Cu and other heavy metal catalysts, which can make Cu and other heavy metal catalysts lose their catalytic effect, thus reducing the generation of dioxin [1].

4.4. Disposal of Ash

(1) Disposal of slag

Waste incineration power generation slag and dust removal facilities to collect the fly ash should be collected, storage, transport and disposal. Furnace slag as general solid waste can be used as roadbed and building materials (brick), etc. for comprehensive utilisation, or sent directly to the landfill for landfill disposal.

(2) Disposal of fly ash

Through the improvement of combustion conditions and the use of flue gas treatment technology, the number of dioxin-like substances discharged into the atmosphere reached the minimum, the adsorbed dioxin-like substances with the particles into the fly ash system. In addition, waste incineration fly ash may be enriched with heavy metals such as lead, mercury, cadmium, etc. The National Hazardous Waste List stipulates that the fly ash generated from the incineration of domestic waste for power generation is a hazardous waste. Waste incineration power plant fly ash temporary [1]

5. Conclusion

This article finds that, Incineration for power generation is an effective waste treatment method that converts solid waste into heat, which in turn is converted into electricity. Particulate matter is one of the main pollutants generated by incineration, mainly as a result of the combustion of waste. High efficiency dust removal technologies such as electrostatic precipitators and bag filters can be used to reduce particulate emissions. Heavy metals are another major pollutant in incinerated waste

and are mainly derived from waste such as plastics. Chemical precipitation, adsorption and ion exchange can be used to remove heavy metals. Acid gases are another pollutant produced during incineration, mainly from sulphur and nitrogen in the waste. To reduce acid gas emissions, desulphurisation and denitrification technologies such as Ca (OH)2 dry desulphurisation and selective catalytic reduction denitrification can be used. Dioxin is a highly toxic substance produced during the combustion process.

To reduce dioxin emissions, methods such as controlling combustion conditions and using efficient dust collectors can be used. Of the various treatment methods, fluidised bed incineration of solid waste has shown superior overall performance. The technology uses a high velocity air stream to mix the waste with sand, through which the sand carries the material to be incinerated at high temperatures. Fluidised bed incineration has a moderate temperature, stable combustion and high thermal efficiency, while being able to effectively remove heavy metals and reduce dioxin emissions. In addition, fluidised bed technology can also achieve the effective utilisation of waste resources and energy, which has a broad application prospect. With the progress of science and technology and the improvement of environmental protection requirements, the future development of incineration power generation technology will pay more attention to the reduction of pollutant emissions and the recycling of resources. In addition to fluidised bed technology, more new technologies and methods can be explored, such as plasma combustion and catalytic combustion.

In conclusion, while incineration for power generation is effective waste treatment, addressing pollutant emissions is critical. With continuous technological progress and in-depth application research, it hoped that a more environmentally friendly and efficient incineration method for power generation will be realized in the future.

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