

The Study Of The Utilization Of The Waste Landfill Methane In Ji Nan

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Non-harmful Disposal Factory in Jinan

Abstract

This article analyzes the current situation of the utilization of the waste landfill methane both at home and abroad. By combining real situation of the methane generation in the Non-harmful Disposal factory in Jinan, the author analyzes, forecasts, studies, and brings forward a countermeasure for the utilization of methane.

Keywords: landfills, methane utilization, research

I. The current situation of the utilization of the waste landfill methane both at home and abroad

1. The current situation of the utilization of the waste landfill methane

With the faster pace of urban modernization and the rapid development of the national economy, the output of the urban life waste is increasing. Consequentially, the problem of environmental pollution is getting worse, and the disposal of waste has drawn the attention of leaders of the government in different levels as well as the concern of the whole society. Nowadays, different countries in the world generally adopt three different ways of disposing waste, sanitary landfill, compost and burning up waste. Among the three methods, though the method of burning up waste and reusing it as a resource is getting popular, the method of landfill still plays a dominant role in many developed countries. The United States of America , Great Britain, Germany and Australia mainly use this method. Even in Japan, a nation that is in serious lacking of land resources, the application of landfill methods nonetheless occupies 20%. The environmental protection organizations in these nations have issued laws and regulations on environmental protection and the recycle and reuse of resources one after another, demanding the collection and disposal of

methane by the landfills, prohibiting the natural release of methane into the air, and thus preventing the pollution of the environment.

After anaerobic fermentation, the life waste produces large quantities of LFG(landfill gas),commonly known as the marsh gas, with its main component methane (CH_4) . The typical components of the marsh gas are as follows:

methane (CH_4) 38 ~ 65% ;

Oxygen (O_2): 1 ~ 2% ;

Carbon Dioxide (CO_2): 30 ~ 48% ;

Hydrogen (H_2): 0.2 ~ 1%。

Many countries in the world such as the United States of America, Great Britain, Germany and Australia have long been using the waste landfill methane. It can mainly be used:

- 1). to burn the steam boiler
- 2). to generate electricity through the use of internal-combustion engine
- 3). as fuel of the power for transportations, as in the case of a methane-fueled car.
- 4). as pipe gas after dehydration depurating process
- 5). to be applied to the carbon dioxide(CO_2) industry.
- 6). as the fuel for producing methanol

The quantity of heat produced by methane is close to that of urban coal gas, which is about $6700\text{kJ}/\text{m}^3$. Energy in every liter of methane equals to that of 0.45 liters of diesel oil or 0.6 liters of petrol, while every stere of methane can generate about 1,25KW electricity. The first European power plant that uses methane to generate electricity was set up in October 1987. In 1999, the first methane power station of China was built and put into use in Tianziling landfill in Hangzhou. In The United State of America, the waste landfill methane is mainly used to generate electricity, while some factories use it as pipe gas after dehydration depurating process. In China, after the successive construction and launch of methane power stations in Tianziling landfill in Hangzhou and Datianshan waste landfill in Guangzhou, It has obtained environmental, social and economical benefits.

2.the harmful aspects of methane

The methane (CH_4) is a potential greenhouse gas which will lead to the ecological unbalance. It causes damage to the ozonosphere twenty times more than the carbon dioxide (CO_2) does, and its affect on global warming ranks number 2, just next to carbon dioxide (CO_2).

- 1).It will cause greenhouse effect. Whether the methane is heavier or lighter than air

depends on the proportion between Carbon Dioxide (CO₂) and Carbon Hydrogen (CH₄). Pure methane has a specific gravity close to that of air (in most cases 1.0). When methane is lighter than the air, it will quickly disperse and form smog that will damage the ozone layer and worsen the situation of global warming.

2). It is easy to explode. When the methane is heavier than the air, it will accumulate in the low-lying areas. If the thickness of methane reaches the margin of explosion, that is, when the methane and the air are mixed at a proportion of 5% to 15%, it will explode at a single spark and start a fire, posing a threat to the surroundings and the people.

3). It will cause pollution of the underground water resource. The volatile organic substances and carbon dioxide contained in the landfill methane can dissolve easily in the underground water. This may break the balance of the carbon dioxide (CO₂) in the underground water, urge dissolution of the terrain around the underwater, causing the rigidification of the water, and consequently affect the health of human beings and animals.

4). It will cause the death of the plant roots near the landfill due to lack of oxygen.

II. The current situation of the waste landfill in Jinan and problems with the utilization of methane

1. The current situation of waste landfill

The Non-harmful Life Waste Comprehensive Disposal Factory covers a total area of 552 mu (about 3.7 hectares). The waste sanitary landfill was put into use in 1998, and it can dispose 1200 tons of waste each day. After its expansion, the disposal capacity will reach 1400 tons each day. It was designed to operate for 9 years. After two years of operation, it has disposed nearly hundreds of thousands of tons of waste. The first phase project of landfill covers 356 × 320 m², occupies land 114,000 m². Artificial high-pressure grout walls are constructed around it to prevent methane from infiltrating. Stone-made blocking walls are built around the landfill so as to increase the landfill capacity, and stone cages are equipped for transmitting methane.

2. The current situation and problems of generating and transmitting the methane

The transformation from organic substances to methane in the waste is a complicated biochemical process. After the waste is filled in, the air (oxygen) left over in it is first used up by the aerobic bacteria. Then under the anaerobic conditions, the anaerobic bacteria and the alkylating bacteria propagate and decompose the organic substances in

the waste and turns them into CH₄ and carbon dioxide (CO₂), etc. Methane is composed of mainly CH₄ and carbon dioxide (CO₂), as well as small proportions of hydrogen (H₂), carbon monoxide (CO) and hydrocarbon. During the generation process, the proportion of main components undergoes a dynamic change. In a stable producing process, there are usually 45%-55% of CH₄, and 40%-45% of carbon dioxide (CO₂). By referring to the experience of other landfills, we adopt a methane production that contains 50% of CH₄, while carbon dioxide and other components accounts for the other 50%.

Many factors will influence the generation of the methane and the speed of anaerobic decomposition, such as the components of the waste (the content and category of the organic substances), the moisture, the temperature, the PH value of the waste, the restraining factors, and the condition under which it is covered and pressed and they vary in different cities, under different climates and under different operation conditions. Experts in abroad have worked out different modes for calculating the total production of methane. These modes have been worked out according to the specific operation conditions with different stresses on factors and operation conditions and the results of these modes of calculation may be different. However, the general rules of them are mostly the same. The most authoritative and representative and widespread mode is the one proposed by the Environmental Protection Agency (EPA). In China, we haven't been working on the landfill for long time and haven't formed a mode of calculating the production of methane. Thus in this article we adopts the EPA's mode to forecast the production of landfill in Jinan (refer to the appendix for the EPA's mode). Since we lacks of standard in processing the landfill, and the pipe line system is not perfect, and other factors, we counted the return rate of methane as 30%. According to above-mentioned criteria, the output of the methane calculated by using the EPA's mode is listed in the following table. It will reach the peak when the landfill is closed, will go on a gradual decline after the closure, and will continue to produce the methane after the closure of the landfill for years.

The landfill is situated in the northeast of the existing waste disposal factory, and covers an area of about 114,000 square meters. We adopt a technique of horizontally unit landfill, which will escalate gradually. The tiptop level of landfill is 21.5 meters above the ground. So far, there are in the landfill 46 vertical stone cages, which are 44 meters apart from each other in an interlaced way. The stone cages have a diameter of 1.5 meters, with its height subject to escalation with the landfill process. The thickest part of the landfill has now reached 7 meters, and has produced large quantities of landfill methane. At present while there is no methane-collecting equipment on the landfill, the stone cages function to disperse the methane produced in the landfill. After the launch of the landfill, an autogeneuous combustion of the landfill methane took place in the winter of 1999, and

lasted for more than 60 days, revealing the hidden trouble of the method.

III. The proposal of the methane utilization plan

With the increase of the waste, the production of methane will grow on a yearly basis. In order to mitigate the harm and environmental pollution caused by methane and ensure security, we have brought forward the methane utilization plan.

1.the estimation of methane production

This article made a forecast of production by applying the EPA's mode. It predicts that the reclaiming of methane in the landfill in Jinan will reach its crest by the year 2008, with a highest production of 37700000 stere meters per year, and a highest reclaiming amount of 11300000 stere meters per year. The landfill will continue its reclaiming function until 2018. During this period, the average production of methane will reach 24300000 stere meters per year, and the average reclaiming amount will reach 7940000 stere meters per year. (The return rate is 30%.) (See table 1)

2. The selection of the methane collection mode

At present, there are very few landfills in the country that can collect methane, and they mainly refer to the foreign experiences to carry out the collection. Generally speaking, there are two ways of collecting methane, namely, vertical collecting and horizontal collecting. Vertical collection is to build a vertical well on the landfill after it is closed in order to collect methane in the landfill, while the horizontal collection is to pave collection pipes horizontally on the landfill during the landfill process. Both methods have their merits and demerits. The vertical collection applies to the collection of methane on the closed landfill or top-covered landfill units.

The characteristic of this method is that it is more convenient to operate on the well and collect methane after the top is covered and the waste is piled up, and the semi diameter of the collection range is larger. However, this method is seldom applied during the landfill process. On the other hand, the horizontal collection applies to the collection before the landfill is closed or during the landfill process. The characteristic of this method is that the collection and landfill can be done at the same time, so it can collect methane in time. The problem with this method is that it is liable to interfere with the landfill process, and the semi diameter of the collection range is relatively small. According to the actual conditions of the landfill, we combined the horizontal way with vertical way in our design. In the vertical way of collection, the existing stone cage well is reconstructed to the vertical well when the landfill reaches a certain escalation, so that methane can be directed out. This method is only available where there is a collecting pipe. Right now the

utilization is restricted in the utilization of landfill methane by using stone cage well.

Table 1 the forecast of landfill methane in Jinan

| Year | The accumulating quantity of landfill | (M ³ /a) The theoretical production of CH ₄ | (M ³ /a)the theoretical production of LFG | (M ³ /a) Forecast production of reclaimable LFG (M ³ /a) |
|-------|---------------------------------------|--|--|---|
| 1999 | 180000 | 990000 | 1980000 | |
| 2000 | 545000 | 2950000 | 5900000 | |
| 2001 | 910000 | 4810000 | 9630000 | 2890000 |
| 2002 | 128000 | 6590000 | 13200000 | 3950000 |
| 2003 | 164000 | 8270000 | 16500000 | 4960000 |
| 2004 | 215000 | 10700000 | 21400000 | 6410000 |
| 2005 | 266000 | 13000000 | 25900000 | 7780000 |
| 2006 | 3170000 | 15200000 | 30300000 | 9090000 |
| 2007 | 3680000 | 17200000 | 34400000 | 103000000 |
| 2008 | 4130000 | 18800000 | 37700000 | 113000000 |
| 2009 | | 17900000 | 35800000 | 107000000 |
| 2010 | | 17000000 | 34100000 | 102000000 |
| 2011 | | 16200000 | 32400000 | 9730000 |
| 2012 | | 15400000 | 30800000 | 9250000 |
| 2013 | | 14700000 | 29300000 | 8800000 |
| 2014 | | 14000000 | 27900000 | 8370000 |
| 2015 | | 13300000 | 26500000 | 7960000 |
| 2016 | | 12600000 | 25200000 | 7570000 |
| 2017 | | 12000000 | 24000000 | 7210000 |
| 2018 | | 11400000 | 22800000 | 6850000 |
| total | 4130000 | 213000000 | 486000000 | 143000000 |

3.The utilization of methane

Methane contains about 50% of CH₄, which produces H₂O and CO₂ after complete combustion. It is a chemical raw material as well as a clean energy, and should be fully utilized. At present, the main utilization of methane are: to be directly used as industrial and civil fuel; to be used to produce electricity so that the energy is transformed to electric power; to be depurated and then used to replace petrol as fuel for vehicles; to be used as industrial raw materials, etc. According to the specific conditions in Non-harmful Disposal Factory in Jinan, that is, the small capital and small capacity of landfill (the comprehensive utilization of electric power requires large amount of methane), this article

focuses on the solution of the safe use of methane, while the rational and fully utilization of methane to produce electricity will be left for future discussion. Now the landfill is using coal as fuel for the refectory and the boiler house, not only adding to the cost but also causing pollution. In methane utilization plan in this article, we discussed the possibility that part of methane be used to replace coal as fuel for the refectory and the boiler house so that we can reduce the cost and mitigate pollution. Taking into consideration that the variable need of the refectory and the boiler house and in order to guarantee the supply as well as satisfy the future utilization and depuration need, we will build gas tanks to store and regulate a needed amount of methane, and then fully combust the rest before releasing it to the air.

To sum up, we propose that the collection and utilization plan of the landfill LFG should be guided by the following principles:

- 1). The methane collection system should be further developed on the basis of the existing landfill stone cage utilization. Besides, the methane should be directed to the upper air and combusted before being released, in order to avoid any occurrence of accidents.

- 2). Provided that the safety is ensured, we should supply methane to the inner faculties such as refectory and the boiler house. The outer application of the depurated methane should be put aside for the time being, though the possibility of its further utilization should be reserved.

- 3). In order to ensure safety, auto inspection and alarm system should be applied to the parameter, which will lead methane to combustion or explosion.

- 4). Provided that the quality and quantity is ensured, the plan should be give priority in use.

Right now the project of methane utilization system has been entrusted to some related designing institute, and will be completed by 2002. The planned total investment is RMB 3400,000. Figure 1 shows its technique flow.

All the methane is expected to be reclaimed by the year 2018.

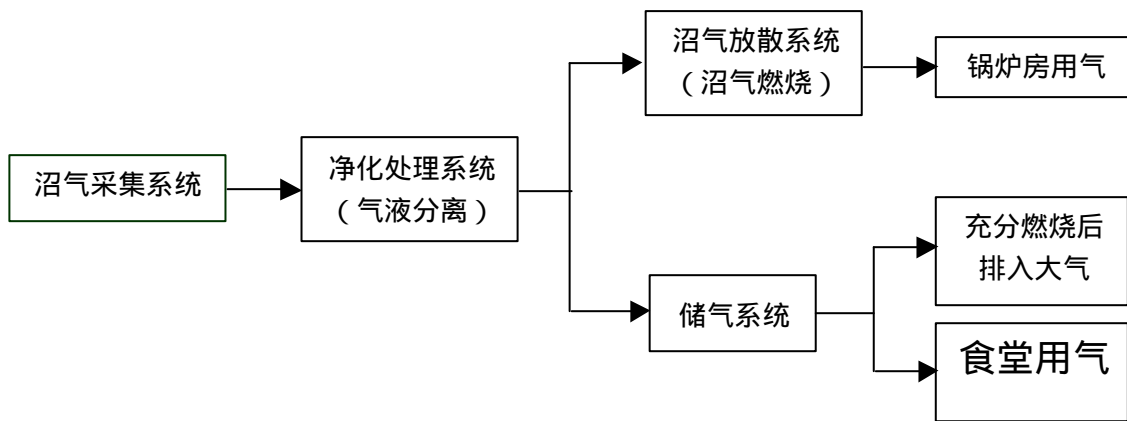


图 1 垃圾填埋场沼气导排系统工艺流程图

Figure 1 Flow Diagram of the Landfill Methane Transmission System

沼气采集系统 methane collecting system

净化处理系统 (气液分离) Depuration system(the separation of gas liquid)

沼气放散系统 (沼气燃烧) methane releasing system(combustion of methane)

储气系统 gas storing system

锅炉房用气 supply for boiler house

充分燃烧后排入大气 released into air after complete combustion

食堂用气 fuel for the refectory