Application of MVC-DI process to the treatment of the municipal landfill leachate

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Abstract. An application of treating the landfill leachate by MVC-DI process is introduced. The leachate evaporation treatment system (MVC) of a landfill decreased by 70% in the treatment capacity, and the effluent quality was not up to the discharge standard. The hot-running test, the cold-stop detection and the analysis of the scale sample have been proposed. After rectification process, the results show the daily treatment capacity is restored to 175 t/d, the effluent quality reaches the design requirement, and the environmental benefits are significant.

Introduction

Along with the rapid development of urbanization, the volume of life garbage has continued increasing. Most city domestic garbage sorting system has not yet formed scale, the garbage landfill mainly consists of the city municipal solid waste and part of the remaining sludge by the municipal sewage treatment plant, which causes the leachate during the landfill process has a complex and volatile water quality [1]. Discharge directly without treatment, it would cause serious environmental pollution.

Landfill leachate composition is complex, belonging to the refractory wastewater, scholars at home and abroad had done a lot of work on handling of the leachate, and found that the routine biochemical, physicochemical treatment effects were poor [2, 3]. At present, there are reverse osmosis [4, 5], leachate recharge [6], land treatment [7], advanced chemical oxidation [8] and bioreactor landfill [9] and so on, widely used as waste leachate treatment technology. The evaporation process for landfill leachate treatment has more engineering application in foreign countries [10], but is less in the domestic literature about the process.

Steam compression evaporate is a stable and continuous evaporation process by automatic control units using the principle of reducing film evaporation. It is mainly composed of steam compressor and heat exchange parts. MVC is the core technology of landfill leachate treatment, which has the characteristics of low energy consumption, permissible water discharge, simple operation and maintenance, and good suitability of water quality [11]. The concentrated solution produced by this process is similar to the reverse osmosis process, which is about 5~10% of the original leachate.

A landfill leachate treatment system adopted mechanical evaporation - Ion exchange (MVC - DI) process. The treatment effect and operation fault in the process, fault analysis and processing and so on has carried out on the preliminary research in this paper.

Landfill leachate system and process

In the MVC recovery processing unit, the landfill leachate enters into an automatic backwash filter, removing a small amount of impurities, and then goes into the evaporator. The moisture, ammonia and other substances separated from the garbage leachate, leaving pollutants in concentrate by effective MVC device. Only some volatile organic acids and ammonia and other pollutants go into steam, eventually exist in distilled water. After the distilled water is collected to the distilled water tank, it is sent to the heat exchange equipment for exchange, leaving the evaporating system and entering the ion exchange system. The process flow is shown in figure 1.

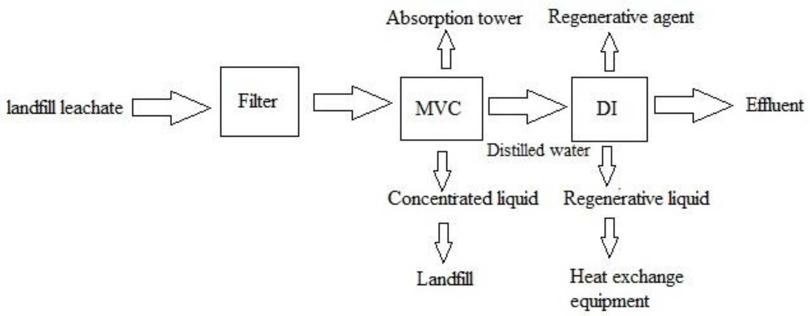

Figure 1. MVC-DI Ammonium recovery process

Landfill leachate water quality

The leachate treatment device was manufactured in 2010 and put into operation in June 2011. Total evaporation capacity is 200t/d, and the design water quality is shown in table 1.

Table 1 the design water quality of the leachate treatment system

CODcr	BOD_5	NH_3-N	TN	TP	SS	coliform group number	oil
⩽ 60mg/L	⩽ 20mg/L	⩽ 8mg/L	⩽ 20mg/L	⩽ 1.5mg/L	⩽ 30mg/L	⩽1000 /L	⩽ 5.0mg/L

The table 1 shows that, after MVC - DI process treatment, the treated water chemical oxygen consumption (COD), five days of biological oxygen demand (BOD_5), ammonia nitrogen (NH_3 – N), total phosphorus, total nitrogen, Soluble solid (SS) and the number of coliform group meet the first level of "standard for pollution control on the landfill site of municipal solid " (GB 16889-2008) and " integrated wastewater discharge standard" (GB 8978-1996). It greatly reduces the living garbage pollution to the surrounding environment.

Since June 2013, under continuous operation conditions, the handling capacity of landfill leachate system decreased to only 2 ~ 2.5 t per hour, and the daily capacity of leachate is about 45t, which is far from the design goal. The processing units frequently irregular fail. After maintaining clean, the first hour capacity reaches 5 m^3 / h, then drops to 2.0 ~ 2.5 m^3 / h sharply, affecting the equipment capacity and stable operation.

Neither the capacity nor the water quality can meet the design requirements, and the main indicators are shown in table 2 after analysis and analysis.

Table 2. The water quality of MVC system in the diagnostic test phase

COD_{Cr}	NH_3-N	TDS	pH
162.4 mg/L	673.3 mg/L	1540μS/cm	9.6

As is seen from table 2, COD, NH_3-N and other indicators are far above the design requirements, and the overall water quality is poor, which can't meet the design requirements.

Determination and analysis methods

Hot running test

Test station

Hot running test is carried out the following units as follows:

(a)Steam generator

(b) Plate heat exchanger

(c) The exhaust heat exchanger

(d) Compressor

(e) Hot well

(f) Heat exchanger

(g) Water pump
(h) Meter
Hot running test results

The hot running test results of the MVC system in the diagnostic test phase are shown in table 3 and compared with the system installation and daily operation phase. It can be seen that the current capacity of leachate treatment is seriously inadequate, the concentration of the liquid is too high, and the raw liquid temperature out of distilled water heat exchanger is low. Also the main temperature is low, and the energy consumption of the electric heater is high.

Table 3. MVC system operation monitoring data

time / items	Installation phase	daily operation phase	diagnostic test phase
Raw liquid flow（t/H）	10.2	3.1	2.37
Concentrate flow（t/H）	0.3	0.4	0.95
Distilled water flow（t/H）	10.1	2.8	1.21
Raw liquid temperature（℃）	28.5	18.1	28.8
Raw liquid temperature out of distilled water heat exchanger（℃）	97.4	82	75.3
Raw liquid temperature out of exhaust heat exchanger (℃)	-	104	98.3
Raw liquid temperature into exhaust heat exchanger (℃)	98.3	86	80.6
Raw liquid temperature out of concentrate heat exchanger（℃）	97.4	91	97.3
Exhaust temperature（℃）	103.0	105	104
Main circulation tube pressure（KPa）	-	112	98
Main temperature（℃）	105.0	96.2	96.3
Hot well temperature（℃）	107.0	102.1	103.1
Compressor outlet temperature（℃）	104.7	110.2	109.2
Distilled water discharge temperature（℃）	27.9	35.6	39.5
Subject pressure (KPa)	8.7	4.6	6.1
Compressor outlet pressure (KPa)	19.2	9.6	23.7
Compressor 1 # vibration rate（Hz）	40	40	40
Compressor 2 # vibration rate（Hz）	40	40	40
Compressor 1 # vibration rate（mm/s）	1.7	1.5	1.9
Compressor 2 # vibration rate（mm/s）	1.4	1.5	1.4
Energy consumption（KW•H）	138.3	-	219.4

Static shutdown detection

nternal inspection

Shut down the MVC system, open the inspection hole of human and hand hole, neutralize the toxic and harmful media and remove the dirt from the container. Under the condition of cold shutdown, an internal inspection and scale analysis of the system is carried out. The internal inspection results are shown in table 4.

Scale analysis

Collect the dirt between the heat exchanger tube bundles and use the X-ray fluorescence spectrometer to analysis. The results are as follows:

(1) Visual inspection and identification

Scale sample is gray-black and irregular shape. There is no obvious change after grinded into powder and dried 1 h in 105℃.

(2) Quantitative analysis of scale sample is shown in table 5.

Table 4 Internal inspection results

Main detection units	Detection result
Evaporation heat transfer agent	Severe fouling between tube bundles, thick dirt covering mist eliminator, no corrosion inside heat exchange tube（figure 2~6）
Electric heating boiler	The heating resistance element had a little white attachment（figure 7）
Compressor	The steam was leaking and the smell was strong and pungent.
Others	No abnormalities were observed.

Table 5 Quantitative analysis of scale sample

Number	Scale composition	Detection method	Percent (%)
1	Ca	X-ray fluorescence spectrometer	11.94
2	P		9.37
3	Si		5.76
4	K		0.21
5	Cl		0.15
6	Mn		0.05
7	Organics		72.24
8	Others		0.28

Figure 2. Severe fouling between tube bundles

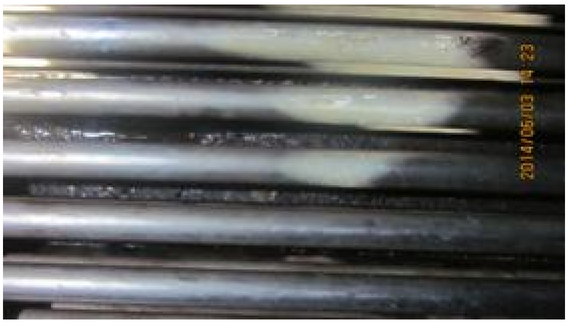

Figure 3. Severe fouling between tube bundles

Figure 4. Thick dirt covering mist eliminator

Figure 5. Thick dirt covering mist eliminator

Figure 6. No corrosion inside heat exchange tube

Figure 7. A little white attachment around heating resistance element

Results and analysis

MVC fouling

The heat transfer tubes between the tube and shell heat exchanger is seriously clogged with dirt. The plate heat exchanger inside is fouled seriously; the fluid is not flowing smoothly. The heat transfer of the MVC heat transfer tube is worsened, and the effective water volume of the shell is greatly reduced.

After scaling, the heat transfer in the inside of the tube is greatly reduced with the temperature of the low-temperature liquid outside the tube. The main temperature is low, so that the amount of the original liquid is greatly reduced and the concentration of the discharge system is larger. The evaporation of the original liquid in the evaporative heat transfer agent decreases, the vapor intake of the compressor is insufficient, and the high temperature steam releases low heat.

The mist eliminator is covered with thick dirt, which reduces the efficiency of the MVC's soda separation, resulting in reduced heat exchange efficiency.

Ion exchange resin (DI) is in failure. Due to the improper maintenance, the water has not been exchanged with ion-exchange resin; which has not kept the ion exchange resin in a wet state, resulting in the drying and failure of cation exchange resin.

Conclusions

Cleaning

(1) Firstly, manual mechanical cleaning of dirt on the MVC's heat transfer tube and other parts (e.g. High pressure water gun, etc.). The dirt and sewage cleaned up should be eliminated from the thermal well below the MVC, avoiding sewage and dirt entering the MVC system piping and plate heat exchanger, causing secondary blockage and pollution.

(2) Chemical cleaning. It can be seen from the analysis of scale samples that the main components of dirt are organic materials and minerals, and the suitable and effective chemical cleaning drugs are selected according to the fouling ingredients, cleaning the heat transfer system.

(3) Adjust the pipeline of plate heat exchanger and increase the cleaning system.

5.2 Replace ion exchange resin, repair DI system, and retrain operators.

5.3 After rectification, the daily processing quantity is restored to 175t/d, which is 87.5% of the design force. The water quality meets the design requirements and meets the water pollutant emission concentration limit specified in the standard for pollution control of the landfill site (GB 16889-2008), reducing the power consumption to 125.6KW• H. During more than two years of operation, it is in good operation, no fouling, which is a significant environmental and social benefit.

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