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The study of sewage sludge thermo-drying efficiency

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Abstract

With the population exploding and improvement of urbanization, the sewage sludge production increases rapidly with the increasing of sewage. However, high water content has been a big problem for sewage sludge treatment and disposal. Thermo-heating is one of the mature methods to reduce the water content in sewage sludge, but the promotion of thermo drying is very restricted by its high cost because of abundant consumption of energy and its expensive equipments. In order to save energy and reduce investment for equipments, we studied the low-temperature thermo-drying efficiency by varying the temperature from 100℃ to 200℃, and changing the shape of the sewage sludge sample, We tried three shapes (cake, cylindrical and spherical) and three temperature (at 150℃,175℃ and 200℃). It is found that cake sludge has the highest drying efficiency and spherical sludge is the lowest in each condition. At 200℃ the drying efficiency could get the highest point.

Keywords: sewage sludge; thermo-heating; moisture content; shape; specific surface

1. Introduction

With the ceaselessly rise of Chinese urban wastewater treatment rate, the yield of sewage sludge is also increased dramatically. In 2009, there are 1992 urban sewage treatment plants in operation, and the treated wastewater amount is 28 billion m3, which produced 20.05 million tons of sludge with 80% water content. And it is estimated that the amount of sludge will soon exceed 30 million tons 0. In addition to the large amount, pathogenic bacteria and microorganism in sludge may pollute the food chain; open dumping of sewage sludge will emit stink smell and other pernicious gases, which surely include NOx, the famous green house gas 0, 0; if sludge discharge without further treatment, heavy metal in sludge

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could cause cultivated land degradation irreversible and may move into the food chain, do harm to environment safety and human health0, 0. So in China sewage sludge treatment and disposal has become one of the major environmental problems. But high water content of sewage sludge is the critical problem for its further treatment and disposal, deep dehydration is necessary 0.

Mechanical dehydration, medicine dehydration and thermo-heating are the more common deep dehydration methods. But in the practically traditional operation it is difficult to decrease the moisture content below 50% by mechanical dehydration; as to medicine dehydration, according to the characteristics of different sludge, the additional ratio of chemicals had better be adjusted. Thermo-heating is a mature method to reduce the water content in sewage sludge and is widely used in Japan and America 0. Although high temperature enhance the drying efficiency, its high cost and the problem about dust explosion are restricting factors 0. In order to save energy and reduce investment for equipments, we set out to study the characteristics of low-temperature heating under various conditions at different temperature and in different shapes. We decided three temperatures as 150℃, 175℃, 200℃ and three shapes as cake, cylindrical and spherical.

2. Experiment Materials and Methods

For sewage sludge sample, fresh sludge sample in this study was collected from one waste water treatment plant in Beijing. The moisture content of the sludge sample is 79%±0.5%. The experimental instruments we used to check the sludge component were listed in Table 1. And the typical element component of this kind of sewage sludge was shown in Table 2.

Table 1. Experimental instruments

Items	Instruments
Metallic element	Atomic Absorption Spectroscopy, HITACHI, Z-2000
TC	JENA multi N/C 2100S and YENA HT1300 Solid module
Cl-	Ion Chromatography, DIONEX, ICS-900

Table 2. Sludge composition

Items	VSS(%)	TC(mg/g)	Cl(mg/g)	K(mg/g)	Fe(mg/g)	Cu(mg/g)	Zn(mg/g)	Mn(mg/g)	Ca(mg/g)	Pb(mg/g)
Contents	52.5	385.4	9.75	1.71	28.26	0.137	1.26	0.255	28.4	0.032

Fresh sludge was made into three shapes (cake, cylindrical and spherical). Table 3 showed the parameters of sludge in three shapes.

Table 3. Parameters of sludge in three shapes

Sludge shape	Weight(g)±1g	Diameter(mm)	Hight(mm)	specific surface(m^{-1})
cake sludge	66.96	6.00	2.00	1.67
cylindrical sludge	66.84	4.00	4.50	1.39
spherical sludge	60.45	5.00		1.20

In our experiment we used the Electro- thermostatic blast oven WGLL-45BE, The voltage of it is 200V/50HZ and the heating power is 1.2kw. Temperature can be controlled between 5-300℃.

Table 4 showed the experimental conditions. Each experiment was conducted twice parallely. The weight of sludge sample was recorded in different time apart at 5min, 10min, 15min, 20min, 30min, until 140min passed.

Table 4. Experimental Conditions

Shape	Temperature	Shape	Temperature	Shape	Temperature
Cylindrical	150℃	Spherical	150℃	Cake	150℃
	175℃		175℃		175℃
	200℃		200℃		200℃

Because of drying temperature is less than 200℃, volatile of organic compounds would evaporated very little and so it was ignored. Instant moisture content can be calculated by the formula (1) ,

$$Y = \frac{m_0 - m_1}{m} \times 100\% \quad (1)$$

m0 is the Real-time weight, m1 is Sludge dry weight, m is initial weight of sludge sample.

3. Results and Discussion

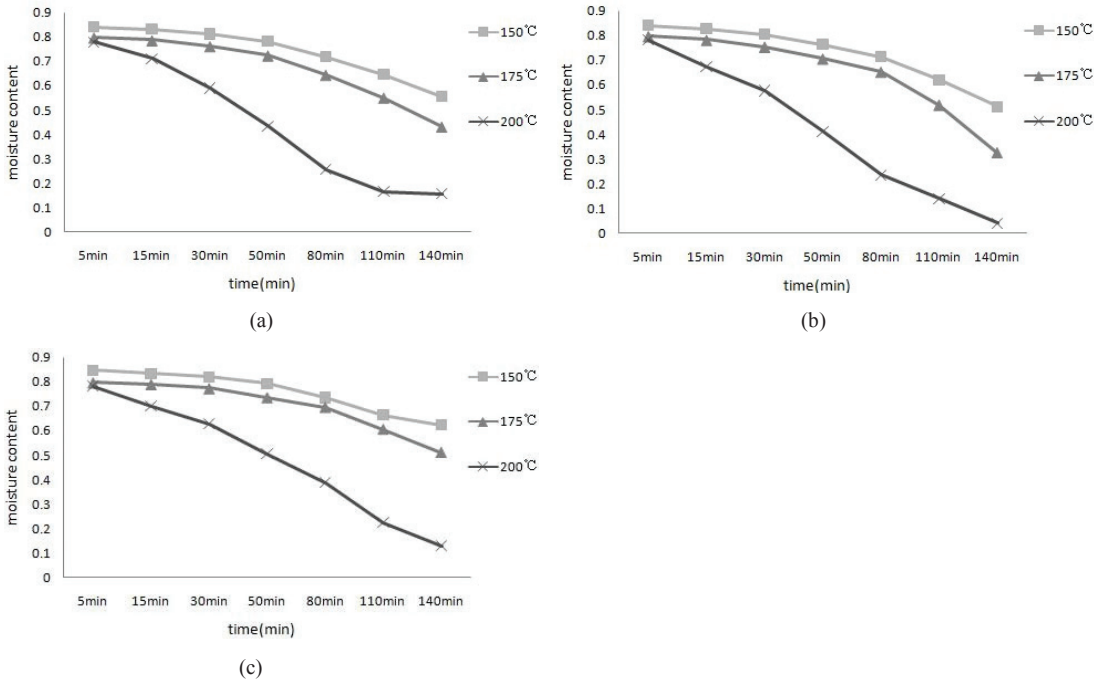

Fig. 1. (a) Drying curves of cylindrical sludge; (b) Drying curves of cake sludge; (c) Drying curves of spherical sludge

As Fig.1(a), (b), (c) above showed, it is obviously that higher temperature could get better dewatering efficiency when there is no blowing. In followed experiments, we found that we need at least 3 hours to make cylindrical and spherical sludge dried to 40% at 150℃, the time is about 1.2 times to 175℃ and 2.22 times to 200℃. Cake sludge is the same.

The cake sludge has the best drying efficiency, and spherical sludge is always the lowest. The three shapes of sludge were made from the same sewage treatment plant and about almost the same weight, so the volume of them is very close. But the specific surface of them is different. It is understandable that if the specific surface is bigger, the water inside the sludge sample has more chances to escape from the inner side of the sludge and more sludge can contact the warmer air, so the drying efficiency is better. In addition, in drying process, sludge samples will shrink heterogeneously to crack or even crush down. More and bigger cracks could enlarge the specific surface of the sludge samples which surely can accelerate the dewatering speed. The creation of cracks is very related to the specific surface of material 0, and sludge with larger specific surface is more likely to crack0. This is because the surface moisture decreased much faster than that of the inside moisture, some researchers have studied the development of cracks during the sludge drying process 0. In this experiment, specific surface of cake sludge is the biggest, so it is understandable that cake sludge has the best drying efficiency.

We can also found there are three stages in whole drying process probably from the curves: speed rising stage, nearly constant speed stage and speed-down stage. In our experiment moisture content above around 60% is the speed rising stage, from about 60% to 30% is the constant speed stage, and then the left is the speed- down stage. In order to ensure drying time more reasonably to save energy, we needed to know more accurate distribution of these stages, further study will be proceed.

4. Conclusion

We try to sum up the conditions that are conductive to improve the sludge drying efficiency. Three temperatures as 150℃, 175℃ and 200℃ have been chosen to research whether increasing heating temperature in small scope can improve drying efficiency significantly or not. We also studied the influence of specific surface on drying efficiency by making the sludge sample in different shape. Based on our experimental results, we may give the following conclusions:

(1) Higher temperature, more efficient the drying. We suggest that to choose appropriate temperature considering with the energy supply and safety condition.

(2) In the experiment, cake sludge has the highest drying efficiency among the three shapes, this is because how much drying efficiency can be improved extent is strongly related to the specific surface of sludge sample. Bigger the specific surface is, faster the drying speed is. And there are three stages in whole drying process: speed-rising stage, constant speed stage and speed-down stage. The trend of drying curves of three shapes is very similar.

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