Deep Dewatering of Municipal Wastewater Sludge by Using Liquefied Dimethyl Ether

1) Ying Huang1, Hongjie Qiao2, Qin Liu2, Dong Zhang1
1) Southeast University, Nanjing, China
2) Jiangning Water Group Co., Ltd, Nanjing, China

1. Introduction

Municipal wastewater sludge is the byproduct of the wastewater treatment. The amount of municipal wastewater sludge increased greatly because of the increase of the waste water quantity. Approximately 5.18 million tons dry municipal wastewater sludge will be generated before 2015 according to the plan released by the General Office of the Chinese State Council (2012). The cost of sludge treatment accounts for 50% - 70% of the total expenses for water resource recovery facility construction. The sludge is difficult to be treated and disposed due to its high moisture concentration.

Dewatering of high-specific-surface-area solid by using liquefied dimethyl ether (DME) is a new technology, which can be explored at room temperature. In this research, the experiment of wastewater sludge dewatering by DME was explored. The influence factors of the extraction time, liquid DME/sludge ratio, stirring speed were studied. In order to study the efficiency of DME dewatering, the change of water content and calorific value in different sludge samples after DME dewatering were analyzed.

2. Materials and methods

2.1 Material and equipment

The sludge sample from Jiangning waste water treatment plant with 82.4% water content was used to discuss the dewatering influence factors. The sludge samples from five wastewater treatment plants were used for analyzing the dewatering of different sludges. The liquefied DME was stored in the liquefied gas steel cylinder.

The main structures of of the experimental equipment include DME cryogenic storage tank (3L), dewatering reactor (1L) with a stirrer, and a gas-liquid separator.

2.2 Experimental method

The liquefied DME was stored in the cryogenic tank. The sludge dewatering experiment was sequencing batch process. In the experiment, 40 g sludge was put into the reactor. Then the valve 1 was opened while the valve 2 was closed, and the liquefied DME was pushed into the dewatering reactor by nitrogen gas. When the liquefied DME quantity reached a certain volume, the valve 1 was closed. After the dewatering reaction was carried out for some time, the valve 2 was opened, the DME solution containing water flowed to the gas-liquid separator, where the liquified DME is vaporized to DME gas under low pressure and separated with the dewatered water.

3 Results and discussion

3.1 Effect of dewatering time

The liquefied DME/sludge ratio (DME/sludge) was controlled at 40ml·g⁻¹, the stirring speed n = 50rad/min, the DME extraction time was changed at 5, 10, 20, 40, 60, 80, 100 min. At the beginning 5 min of the dewatering reaction, the water content of the sludge decreases dramatically with the extraction time, decreases from 82.4% to 47.4% and the dewatering efficiency reaches 80.7%. But after 5 minutes, the water content changes slowly. It becomes almost constant of 25.0% when the dewatering time is longer than 45 min, and the dewatering efficiency reaches 92.1%. Therefore, 45 min is determined to be the optimum reaction time.
3.2 Effect of DME/sludge ratio

At the optimum reaction time 45 min, and the stirring speed $n = 50 \text{ rad/min}$, the water content of the sludge dewatered at Liquefied DME/sludge ratio DME/sludge = 5, 11, 17, 23, 35 ml/g was measured. The water content decreases dramatically from 82.4% to 33.5% with the increase of DME/sludge ratio when DME/sludge $<25 \text{ ml/g}$, and the dewatering efficiency increases to 90%. When DME/sludge $\geq 25 \text{ ml/g}$, dewatering efficiency increases slowly. The optimum liquefied DME/sludge ratio is determined to be 25 ml/g with the economic consideration. When DME/sludge = 35 ml/g, 97.1% of dewatering rate is obtained and the water content changes from 82.4% to 12.1%.

3.3 Dewatering efficiency of wastewater sludge from different water resource recovery facility

The sludge samples were collected from five water resource recovery facilities with different treatment process. No. 1, 2, 4, 5 sludge samples were obtained from municipal water resource recovery facilities; No. 3 sludge sample was from a chemical fiber water resource recovery facility.

These sludge samples were dewatered under the optimum condition: DME/sludge = 25 ml/g, dewatering time $t = 45 \text{ min}$ and stirring speed $n = 50 \text{ rad/min}$. The water content change and the dewatering efficiency of these five kinds of sludge samples were shown in Fig. 1.

We found that all sludge samples were dewatered efficiently. The highest dewatering efficiency was 94.9%. The dewatering efficiency of No.4 sludge sample was a little lower of 84.6% than other samples, which was maybe caused by the lower water content of the original No.4 sludge sample. Although the water content and organic mass content of No.3 was much higher than other sludge samples, its dewatering efficiency was still high of 94.0%, which indicated that DME dewatering technique could dewater different sludge including the municipal wastewater sludge and chemical fiber wastewater sludge. Except No. 3 sludge sample, the water contents of other municipal wastewater sludge samples were decreased from about 80% to <25%. The lowest water content of dewatered sludge was 17.3% of No. 2 municipal wastewater sludge sample.

3.5 Change of calorific value in sludge after dewatering

The net calorific values of all sludge samples increased dramatically because of the water contents decreased greatly (Fig. 1). The bomb calorific value of all sludge samples decreased slightly, the highest decreasing is 10.9% of No. 3 sludge. The gross calorific value also decreased slightly, the highest decreasing is 10.4% of No. 3 sludge. The decreasing of the bomb calorific value and the gross calorific value was because some organic mass was transferred to the dewatered water.

![Fig. 6 Dewatering results of five sludge samples from different water resource recovery facilities;](image)

(a) water content of the sludge before and after dewatering; (b) dewatering efficiency under optimum condition

4 Conclusions

Under the dewatering condition of DME/sludge = 25 ml/g, $t = 45 \text{ min}$, $n = 50 \text{ rad/min}$, the water content of municipal wastewater sludge samples were decreased dramatically from about 80% to <25%. The net calorific values of all sludge samples increased dramatically because of the water contents decreased greatly. The bomb calorific value and the gross calorific value of all sludge samples decreased slightly. DME dewatering process is benefit to the following sludge incineration.