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A Review on Sludge Drying after High Pressure Filter Pressing

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Abstract

Sludge drying is a key step in municipal sludge treatment. After mechanical dewatering, the water content of sludge is usually between 50% and 70%, which needs further drying. The main drying technologies include thermal drying, solar drying, ultrasonic drying and microwave drying, among which thermal drying technology is the most mature. Research shows that low-temperature drying technology has obvious advantages in reducing the release of harmful substances, energy consumption and cost. In terms of technology application, domestic sludge drying process is mainly divided into direct drying and indirect drying. Direct drying directly evaporates water through high-temperature gas, while indirect drying makes use of heat conduction effect to contact with high-temperature media. At present, indirect drying technology is mainly used in China, such as paddle type, disc type and thin layer drying. In particular, the low-temperature heat pump drying technology excels in terms of safety, footprint and energy consumption, with its ability to operate at lower temperatures, reduce the release of hazardous gases, and achieve environmental and economic benefits in a closed-cycle mode. This technology is suitable for small and medium-sized wastewater treatment plants and shows clear advantages in cases of budgetary constraints.

Keywords

Sludge Drying; Low Temperature Drying; Heat Pump Drying; Environmentally Friendly.

1. Overview of Sludge Drying Research

Municipal sludge with high water content has a water content of 50%-70% after mechanical dewatering processes such as belt filter press, plate and frame filter press or centrifugal dewatering, which does not meet the standards for reduction and resource utilization, so the mechanically dewatered sludge still needs further drying treatment.

Dewatered sludge needs to be dried when it cannot meet the requirement of sludge water content for subsequent disposal methods. Sludge drying refers to the operation of further dewatering of sludge after it has been mechanically dewatered [1]. According to different drying methods, sludge drying technologies mainly include thermal drying, solar drying, ultrasonic drying, and microwave heating drying. The most widely researched and mature is the thermal drying technology.

2. Domestic and International Research Status and Trends

Sludge drying technology is an important means to realize the harmless treatment and resource utilization of sludge, which has received extensive attention worldwide.Gross T S C et al [2] evaluated and compared the types of direct and indirect heating processes in sludge drying plants in Switzerland and Belgium, respectively, and investigated the energy demand and energy utilization of the two processes, and presented their viewpoints on the existing changes in the sludge disposal industry in the UK. put forward their own viewpoints.Ruiz T et al [3] investigated the water evaporation and solid shrinkage during convective drying of residual

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municipal sludge at 30 °C, obtained the kinetic curves of drying deformation, and proposed a coupled analysis method of water content and volumetric shrinkage, which can be used to predict the internal changes of sludge during drying, and provide a basis for the selection of different types of sludge drying Ma et al by studied the drying process of sludge particles at a constant temperature of 100-200°C and found that the sludge drying process includes four periods: preheating period, constant speed drying period, the first cooling drying period and the second cooling drying period, and the drying rate is greatly affected by the drying temperature [4]. When the drying temperature is less than 100°C, the organic components are not volatile in the drying process, which is conducive to the resource utilization of sludge [5]. Li Jinping et al [6] studied the changes in the content of different forms of heavy metals in sludge after drying at different temperatures, such as 150°C, 300°C, 500° and 800°C, and found that heavy metal elements such as Cu and Pb would be transformed from unstable forms to more stable forms after high temperature drying of sludge, which indicated that high temperature drying of sludge has the effect of stabilizing the forms of internal heavy metals. Eddie Chu et al. [7] explored the degree of release of some organic volatile pollutants such as benzene and phenol in the drying process. When the drying temperature was between 50 and 300°C, the total phenol release of domestic sludge and some industrial sludge was between 4.30-161.80ug/m3; when the drying temperature was lower than 150°C, the phenol release at this time was less than 6% of the total release. Low-temperature drying can effectively reduce the release of harmful substances and lower the initial investment and the cost of tail gas treatment in the drying process.

To sum up, low-temperature sludge drying technology has low energy consumption, and due to the low drying temperature, the emission of malodorous gases is relatively small, the calorific value of sludge can be preserved to a high degree, and the dosage is small, which does not affect the subsequent treatment and utilization of sludge, and it is a necessary means of sludge reduction and resource utilization. Among them, the low temperature heat pump drying technology has high heat pump heating efficiency, which can save energy and reduce carbon; the whole process is closed, and there is almost no leakage of malodorous gas. Solar low-temperature drying technology to make full use of solar energy this clean energy, in the national "carbon peak, carbon neutral" background, the use of clean energy is bound to become one of the main ways of sludge drying, and vigorously develop solar low-temperature drying technology in line with the national strategic needs. Generally speaking, low-temperature drying technology in sludge drying and other materials drying will be very promising, worthy of further research and application.

3. Sludge Drying Technology and Application

In the past period of time, the treatment processes for sludge reduction in China are mainly divided into two categories: direct drying and indirect drying [8]. Direct drying refers to the direct contact between the wet sludge and the high temperature gas, which provides the heat needed for the evaporation of the water in the sludge, and then the evaporated gas is taken away by the high temperature gas for further treatment. Indirect drying means that the sludge is not in direct contact with the heat source, and the water in the sludge is evaporated by using the heat conduction effect and contacting with the outer wall of the metal pipe that is passed into the high-temperature heating medium (usually steam or heat-conducting oil). At present, most of the domestic projects for sludge drying use indirect drying, commonly paddle drying, disc drying and thin-layer drying [9].

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Table 1. Comparison of low-temperature heat pump drying technology with other technologies

dryer	Cryogenic heat pump drying	Paddle Sludge Dryer Drying	Rotary Sludge Dryer Drying	Thin-layer drying	Rotary Sludge Dryer Drying
drying temperature	40 ~ 75 ℃	> 150 ℃	> 150 ℃	> 150 ℃	200 ~ 300 ℃
Drying method	hot air circulation	thermal conduction	thermal conduction	thermal conduction	heat convection
Heating method	heat pumps	Steam, thermal oil	Steam, thermal oil	Steam	Hot air, waste heat flue gas
Dust content	not	high	high	high	extremely high
safety	Low Temperature Safety	High operating temperature	High operating temperature, nitrogen filling required	High operating temperature	High operating temperature and filling degree
exhaust gas treatment	not	Requires deodorization system	Requires deodorization system	Requires deodorization system	Requires deodorization system
mechanical wear	not	large	large	large	large

Comparison of Table 1. and review of the data shows that cryogenic drying technology has considerable advantages over other equipment in terms of safety, footprint and energy consumption [10].

The basic principle of heat pump cryogenic drying is to expose a solid-liquid mixture to a flow of hot air, in which the liquid portion (usually water) slowly evaporates, leaving a solid residue as the product of drying [11]. Traditionally, drying can be categorized into low temperature drying and high temperature drying. Drying at low temperatures close to the ambient temperature is considered to be less damaging to the nutrient or biological content of the dried samples, such as when drying crops that are intended to be replanted [12], a theory that is supported by several studies. Drying close to room temperature in hot air dryers such as heat pump dryers and heat flow circulation ovens, living cells and bioactive molecules are usually sensitive to temperature. Conventional water removal methods, such as spray drying and freeze drying, usually operate at very low or high temperatures and can easily denature biomolecules unless expensive protective agents are added. Heat pump cryodrying eliminates the loss of bioactivity due to high temperatures because its technology can operate at much milder temperatures, closer to the atmospheric conditions where microorganisms naturally reside.

4. Conclusion

In summary, heat pump low-temperature drying is often applied to dry crops. Its low energy consumption, simple operation and high safety make it widely used in small and medium-sized sewage treatment plants. The release of harmful gases can be effectively controlled when the closed cycle mode is used. And in the drying process, only condensate is discharged, almost no other impurities are discharged, which is both environmentally friendly and hygienic [13], and it can save a lot of economic budget for subsequent treatment in the construction, which is very suitable for the installation and use by manufacturers and regions that need the equipment for sludge drying but have limited budgets.

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