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污泥过热蒸汽与热风薄层干燥的湿分扩散系数和活化能分析

Analysis of moisture diffusion and activation energy in superheated steam and hot air sludge thin layer drying

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中文关键词: 污泥处理,干燥,模型,有效扩散系数,活化能

英文关键词:sludge disposal drying models effective diffusivity coefficient activation energy

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中文摘要:

为研究污泥薄层在过热蒸汽干燥和热风干燥过程中有效扩散系数及活化能，搭建了常压内循环式干燥试验装置。在160~280℃温度下，分别对4、10 mm污泥薄层进行过热蒸汽干燥和热风干燥。利用Fick扩散模型，建立有效扩散系数和干燥时间的关系，试验得到4 mm污泥薄层过热蒸汽干燥与热风干燥的有效扩散系数范围分别为7.1515×10-9～2.4852×10-8m2/s和1.2414×10-8～2.2769×10-8 m2/s；10 mm污泥薄层过热蒸汽干燥与热风干燥的有效扩散系数范围分别为1.9659×10-8～5.8811×10-8 m2/s和2.8042×10-8～5.6095×10-8 m2/s。根据Arrhenius经验公式建立有效扩散系数与温度的关系，得到4、10 mm污泥薄层过热蒸汽干燥和热风干燥的平均活化能分别为21.173、18.085和9.485、11.191 kJ/mol。用Midilli薄层干燥模型模拟得出的过热蒸汽干燥与热风干燥有效扩散系数和活化能与试验值基本吻合。研究结果表明：当温度超过260℃时，过热蒸汽干燥的有效扩散系数比热风干燥有效扩散系数大。过热蒸汽干燥有效扩散系数随温度增加的趋势近乎成一条斜直线，而热风干燥的有效扩散系数增加趋势则是曲线性，说明热风干燥过程中存在氧化、燃烧的可能。文章确定了污泥薄层干燥有效扩散系数值及过热蒸汽干燥逆转点温度，为污泥过热蒸汽干燥参数优化与干燥设备设计提供参考。

英文摘要:

Abstract: Sewage sludge is generated in wastewater treatment processes. It has a solids content of about 1-2% typically. The key step to treating sludge is dewatering.. Dewatering of sludge by belt presses, filters, and centrifuges can lead to dry solids contents in the range of 15-25%. This step can substantially reduce the volume of the sludge. Characteristics of sludge include high water content, bulk mass, and containment of pathogenic microorganisms. Landfilling of sludge has the disadvantages of occupying land and causing secondary pollutions, especially to groundwater. Thermal drying of dewatered sludge is another step to reduce the volume of dewatered sludge. The drying process consists of complex mechanisms such as molecular diffusion, capillary flow, Knudsen flow, water uptake kinetics flow, and surface diffusion.In order to study the effective diffusion coefficient and the activation energy characteristics of the sludge layer in the process of superheated steam drying and hot air drying, an internal-circulation drying test-bed under normal pressure was built to carry out superheated steam drying and hot air drying tests on sludge layers with thicknesses of 4 mm and 10 mm respectively at the temperature range of 160-280℃. The linear relationship between effective diffusion coefficient and drying time was established through the Fick diffusion model. It was found that the effective diffusion coefficients for the 4 mm sludge layer ranged 7.1515×10-9-2.4852×10-8m2/s and 1.2414×10-8-2.2769×10-8 m2/s for superheated steam drying and hot air drying respectively. The effective diffusion coefficients for the 10 mm sludge layer ranged 1.9659×10-8-5.8811×10-8 m2/s and 2.8042×10-8- 5.6095×10-8 m2/s for superheated steam drying and hot air drying respectively. The linear relationship between effective diffusion coefficient and temperature was established based on the Arrhenius empirical formula. Thus, the average activation energies of 4 and 10 mm sludge layers can be obtained respectively as 21.173 and 18.085 kJ/mol by superheated steam drying and 9.485, 11.191 kJ/mol by hot air drying. These values are mostly in conformity with the effective diffusion coefficient and activation energy obtained by the Midilli thin layer drying model This test showed that when temperature exceeds 260℃, the effective diffusion coefficient of a sludge layer by superheated steam drying is greater than that created by hot air drying. Values obtained showed a linear increase in diffusion coefficients to temperature by superheated steam drying but a curve in hot air drying, suggesting the possibility of oxidation and combustion of the sludge layer by hot air drying.

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