

污水快速渗滤处理系统水力负荷周期的设计

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摘要 水力负荷周期是污水快速渗滤处理系统中最关键的运行参数。本研究在面积为 80 m^2 的啤酒废水现场中型试验中, 分别得出了淹水期入渗速率递减曲线和落干期入渗速率恢复曲线, 它们可分别用指数方程和对数方程来表达。据此提出了一种以追求最大水力负荷为目标时水力负荷周期的定量设计方法。将其应用于该次试验后得出的结果为 1.78 d 淹水、 2.77 d 落干。计算结果与实测结果比较表明, 该方法是可行的。

关键词 快速渗滤, 水力负荷, 水力负荷周期, 入渗速率。

水力负荷周期是快速渗滤系统最重要的设计参数, 它决定着系统对污染物的去除效果及其水力容量的充分发挥, 同时它也是快速渗滤系统研究中的难点之一。本研究是在试验的基础上, 试图提出一种以追求最优水力负荷为目标的水力负荷周期设计方法: 入渗速率递减-恢复曲线法。

1 入渗速率递减和恢复曲线

本试验是夏秋季节在河南开封市进行的。快速渗滤系统表层为细砂, 渗池面积 80 m^2 , 试验用污水为经过一级处理后的啤酒废水。废水中悬浮固体含量为 $100-200 \text{ mg/L}$, BOD_5 , $500-1200 \text{ mg/L}$, COD_Cr , $1000-2000 \text{ mg/L}$ 。淹水深度 30 cm 。通过连续淹水得出入渗速率递减曲线。然后采用固定的淹水期和不同的落干期, 从而得出不同落干期时入渗速率的恢复情况, 见图1。

北京农业大学在其“城市人工土快速渗滤系统研究”中得出的入渗速率递减和恢复曲线与本试验结果类似*。

统计分析结果表明, 上述入渗速率递减曲线可用指数方程 $V = ae^{bt}$ 来描述。入渗速率恢复曲线在每次淹水结束, 开始落干时, 均有一段时间的迟缓期 t_d 。在 t_d 期内, 入渗速率基本上无恢复, 近于与 t 轴平行。若不考虑迟缓期 t_d ,

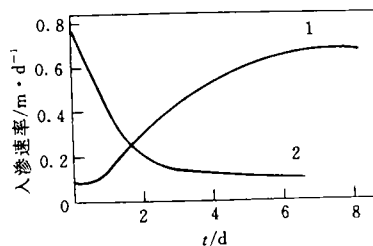


图1 入渗速率递减及恢复曲线

1. 恢复曲线 2. 递减曲线

则恢复曲线符合对数方程 $V = c + d \ln t$ 。结果为:

$$\text{递减曲线 } V = 0.809 e^{-0.692t} \quad r = 0.986 \quad (1)$$

$$\text{恢复曲线 } V = 0.210 + 0.226 \ln t \quad r = 0.986 \quad (2)$$

关于迟缓期 t_d , Flushing Meadows 工程研究结果中表现最为明显, 其物理意义可能为: 落干期开始意味着渗池表面已无残水, 但表层水分的下移仍需一个过程, 在这个过程中, 表层未能恢复至好气环境, 堵塞物的分解未能开始, 另外, 由于长时间淹水, 表层好氧微生物活性降低, 落干期开始后, 好氧微生物的恢复需要一个过程。因此, t_d 与淹水期的长短及淹水终止时的入渗速率有关。

* 北京农业大学, 城市人工土快速渗滤研究, 1990。
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2 最优水力负荷周期的计算方法

周期的计算方法见图2。

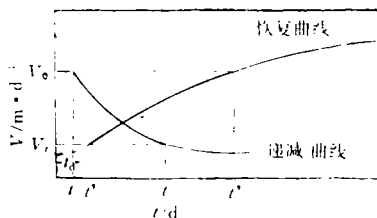


图2 最优水力负荷周期计算方法

假定某一淹水期开始时的入渗速率为 V_0 ，淹水期结束时的入渗速率为 V_t ，即在递减曲线上对应的时刻分别为 t_0 、 t ，则为了保持稳定的入渗条件，在落干期，入渗速率必须恢复至 V_0 ，否则，将会造成系统入渗条件的不断恶化。这样，有下列方程：

$$\text{淹水期：} \quad \text{TF} = t - t_0 \quad (3)$$

入渗速率恢复期

$$\begin{aligned} t' - t'_0 &= e^{\frac{V_0 - c}{d}} - e^{\frac{V_t - c}{d}} \\ &= e^{\frac{ae^{bt_0} - c}{d}} - e^{\frac{ae^{bt} - c}{d}} \end{aligned} \quad (4)$$

由于每一落干期前均有一迟缓期 t_d ，所以：

$$\text{落干期：} \quad \text{TD} = t_d + t' - t'_0 \quad (5)$$

前已讨论， t_d 与淹水期长短及淹水终止时入渗速率 V_t 有关，实际即与淹水期在入渗速率递减曲线上所处的位置有关，而其位置主要是与淹水起始时刻 t_0 有关。因此，为简化计算，按下式计算：

$$t_d = \alpha t_0 \quad (6)$$

这里将 α 称为迟缓系数，其值通常不大于 1。这样，落干期成为：

$$\text{TD} = t_d + t' - t'_0 = \alpha t_0 + e^{\frac{ae^{bt_0} - c}{d}} - e^{\frac{ae^{bt} - c}{d}} \quad (7)$$

淹水时段 t_0 - t 累计入渗量：

$$l = \int_{t_0}^t ae^{bt} dt = \frac{a}{b} (e^{bt} - e^{bt_0}) \quad (8)$$

则水力负荷为：

$$L = \frac{l}{\text{TD} + \text{TF}} =$$

$$\frac{\frac{a}{b} (e^{bt} - e^{bt_0})}{(t - t_0) + (\alpha t_0 + e^{\frac{ae^{bt_0} - c}{d}} - e^{\frac{ae^{bt} - c}{d}})} \quad (9)$$

这样，问题成为在 t/t_0 域内求 L 的极大值。

L 对 t 求导：

$$\begin{aligned} \frac{dL}{dt} &= \left\{ \frac{a^2}{b} e^{\frac{ae^{bt} + 2bdt - c}{d}} - (a + \frac{a^2}{d} e^{bt_0}) e^{\frac{ae^{bt} + dbt - c}{d}} \right. \\ &\quad \left. + ae^{bt} + [ae^{\frac{ae^{bt_0} - c}{d}} - (1 - \alpha)at_0 - \frac{a}{b}] e^{bt} + \frac{b}{a} e^{bt_0} \right\} \\ &\quad \left[t - (1 - \alpha)t_0 + e^{\frac{ae^{bt_0} - c}{d}} - e^{\frac{ae^{bt} - c}{d}} \right] = \frac{F(t)}{G(t)} \quad (10) \end{aligned}$$

由于问题的复杂性，关于极值存在与否，这里不进行严格的数学讨论。试算表明， L 在 $t > t_0$ 域内有且仅有一极大值。

令方程 $\frac{dL}{dt} = 0$ ，则 $F(t) = 0$ 之解即为 L 的极大值点。方程 $F(t) = 0$ 可采用牛顿迭代法求解。

上述方程之解 $t_{\max}$ 即为当淹水期初始时刻为 t_0 时，使水力负荷达到最大的淹水期终止时刻。将 $t_{\max}$ 代入式 (3)、(7)、(9) 可分别求出淹水期、落干期及相应的水力负荷。

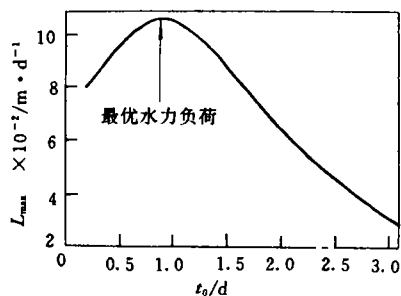
当选择不同的 t_0 值时，可得出各自相应的水力负荷极大值 $L_{\max}$ 及 TF、TD。然后，将 $L_{\max}$ 作为纵轴， t_0 作为横轴作图可得出一曲线，该曲线上的极大值即为最终的水力负荷极大值。

3 计算结果

本次试验中， $a = 0.809$ ， $b = -0.692$ ， $c = 0.210$ ， $d = 0.2269$ (见式 (1)、(2))， α 取 0.5。计算结果见表 1 及图 3。

表1 最优水力负荷周期计算结果

t_0 (d)	$t_{\max}$ (d)	$L_{\max}$ (m/d)	TF (d)	TD (d)
0.5	2.76	0.0910	2.36	4.55
0.8	2.58	0.1046	1.78	2.77
1.0	2.58	0.1043	1.58	2.15
1.5	2.93	0.0882	1.43	1.52
2.0	3.49	0.0647	1.49	1.42
3.0	4.69	0.0301	1.69	1.66

图3 $t_0-L_{\max}$ 曲线

结果表明, 当 $t_0=0.8$ d, 淹水期 1.78 d, 落干期 2.77 d 时, 水力负荷最高, 为 0.1046 m/d, 最优水力负荷周期为 1.78 d 淹水, 2.77 d 落干。

本次试验实际运行时采用 2 d 淹水、5 d 落干的水力负荷周期, 但由于残水(约 20 cm)下渗约需 0.5 天时间, 实际水力负荷周期应为 2.5 d 淹水, 4.5 d 落干。这种运行方式下实际的水力负荷为 0.09 m/d。与计算结果 $t_0=0.5$ d 时, 淹水 2.36 d, 落干 4.55 d, 水力负荷 $L_{\max}=0.0910$ m/d 基本相同, 说明本方法是可行的。根据计算结果, 若试验采用更短的水力负荷周期如 1.78 d 淹水, 2.77 d 落干, 其水力负荷可望有所提高。

4 结论

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mann 规则。为动力学允许过程。

Koopmans 定理指出, 分子轨道能量的负值等于占据该轨道的电子的电离势。因此, 实验上研究双自由基 NH 、 CH_2 、 CCl_2 与 O_3 的反应时, 在光电子能谱上应该能够看到与表 4 轨道能级相应的谱线, 从而证实这些中间体及产物的存在, 并进而证实这些双自由基与 O_3 的反应机制。

3 结论

本文给出一种不计算反应过渡态, 将热力学分析和 Woodward-Hoffman 规则相结合研究复杂反应机理的方法。理论计算表明, 大气中氮氮和氟氯烃等分解生成的双自由基 NH 、

(1) 本文给出了一种以最大水力负荷为目标时水力负荷周期的设计方法。其基本过程是: 当入渗速率递减和恢复曲线已知后, 可使用程序进行计算, 给定不同的 t_0 , 得出相应的 $L_{\max}$ 值, 并据此作 $t_0-L_{\max}$ 曲线, 曲线中的极值点即为最终计算的最大水力负荷, 相应的淹水和落干期就是最优水力负荷周期。

(2) 上述计算的基础是入渗速率递减与恢复曲线, 这些曲线应在实际现场试验中获得。实际结果可能不符合指数或对数曲线而为其它类型的方程, 但其计算方法是类似的。另外, 不同季节时曲线的形状是不同的, 应分别计算。

(3) 迟缓系数 α 的选择具有人为性, 关于迟缓期的确定有待于进一步研究。

(4) 试验结果与计算结果相比表明, 本方法是可行的。

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CH_2 、 CCl_2 等都能与 O_3 发生反应, 从而破坏大气层。有关反应为 2 步反应, 首先臭氧 O_3 与双自由基反应生成较稳定的中间体, 该中间体在光照下分解成产物。

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tration increased; and the toxicity (EC₅₀, 96 h.) of rare-earth elements on *Chlorella pyrenoides* was in sequence as: Nd > Ce > Pr > La > mixture of them, but little difference.

Key words: rare-earth element, *Chlorella pyrenoides*, effect on growth and reproduction.

Study on in-Bed Desulfurization within Fluidized Bed Coal Gasifier. Bu Xuepeng et al. (Beijing Research Institute of Coal Chemistry, Central Coal Mining Research Institute, Beijing 100013); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 39–41

The data obtained from the tests indicated that both limestone and dolomite can be used effectively for capturing sulfur during the gasification of high sulfur coals. Desulfurization efficiencies can be improved with increasing the Ca/S molar ratio, the efficiencies were maximum when the ratio was 3, or by increasing total sulfur in raw coals. The effect of operating pressure on desulfurization efficiency is determined by temperature and partial pressure of carbon dioxide. The desulfurization rate was range of 50%–85% under different conditions.

Key words: fluidized bed gasification, in-bed desulfurization, desulfurization sorbent.

Mass Transfer-Reaction Process Mechanism of Wet Flue Gas Desulfurization with Lime. Wu Zhongbiao and Tan Tian'en (Dept. of Chem. Eng., Zhejiang University, Hangzhou 310027); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 42–44

By studying experimentally wet flue gas desulfurization with lime as absorbent and rotating-stream-tray scrubber as absorber, the mass transfer and reaction process on Ca(OH)₂ slurry absorbing SO₂ is analyzed. Furthermore, the process mechanism is proposed. According to the mechanism, the total reaction rate is controlled by SO₂ diffusion in gas phase and Ca(OH)₂ dissolution and diffusion in liquid phase. The reaction process can be divided into three stages, the stage controlled by gas phase resistance, by gas phase and liquid phase resistance, and by liquid phase resistance. The process mechanism has been verified by the experiment. These results will help to optimize the design and operation of the industrial installation of wet flue gas desulfurization with lime.

Key words: flue gas desulfurization, mechanism, mass transfer-reaction process, lime, wet.

Effects of Three Sorts of Anaerobic Promoter on Anaerobic Digestion of the Waste Liquor from Ammonium Sulfite Pulping of Straws. Zhang Renquan (Dept. of Resource and Environ. Sci., Hefei Univ. of Technol., Hefei 230009); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 45–46

The effects of activated carbon, ferrous sulphate and bentonite on anaerobic digestion of the waste liquor from ammonium sulfite pulping of straws have been analysed on the basis of the experimental results of anaerobic batch assays with the waste liquor. The results indicate that, with a dose of 2.5 g/L, each sort of the anaerobic promoter can substantially promote anaerobic digestion of the waste liquor, which can increase 30 day total gas production of the anaerobic system by 16.1%, 13.9% and 26.1% respectively compared with the control. The ac-

tion mechanisms of the three sorts of anaerobic promoter have been discussed preliminarily.

Key words: anaerobic promoter, waste liquor from ammonium sulfite pulping of straws, anaerobic digestion, action mechanisms.

Using Hydra Reaggregations Evaluating the Safety of Two Kinds of Food Additives. Cheng Qinyao et al. (Dept. of Biology, Anhui University, Hefei 230039); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 47–48

This paper studied the safety of two kinds of food additives using *Hydra* reaggregations. The results showed that both sodium benzoate and sodium nitrite inhibited the growth of reaggregations. The minimum effective concentrations were 34.7×10^{-4} mol/L and 2.9×10^{-3} mol/L respectively. In addition, the negative correlation existed between the depolymerization time of the reaggregations and the concentration of food additives. Therefore, *Hydra* reaggregations technique will be a rapid screening method for predicting the potential toxicity of food additives.

Key words: *Hydra* reaggregation, food additive, evaluation safety, rapid screening.

A Study on Long-wave Pulsed Electromagnetic Fields Around A Long Range Navigation Station. Yao Gengdong et al. (School of Public Health, Zhejiang Medical University, Hangzhou 310031); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 49–50

A measurement and a theoretical calculation of long-wave pulsed electromagnetic fields (PEMF) around the antenna of the first long range navigation station in China were conducted. The results showed that the electric field intensities were 0.5–3.6 V/m (RMS) corresponding to peak values of 38.5–276.9 V/m in the PEMF generating room; in the residential area which is 850–1100 m away from the antenna, the electric fields were 0.7–3.9 V/m corresponding to peak values of 53.9–300.3 V/m; the PEMF decreased in environment with the distance away from the antenna and when the distance is over 1200 m from it, the fields tended towards minimum.

Key words: pulse, long-wave, environment, electric field intensity.

Determination of Hydraulic Load Cycle in Rapid Infiltration Treatment System of Waste Water. Wu Yongfeng et al. (Dept. of Environ. Sci., China University of Geosciences, Beijing, 100083); *Chin. J. Environ. Sci.*, 17(2), 1996, pp. 51–53

Hydraulic load cycle is the most important operation parameter in rapid infiltration treatment system of waste water. The decrease curve and recovery curve of infiltration rate in flooding and drying periods are obtained from the in situ test with the area of 80 m² and flooded with brewery waste water. The curves can be expressed with exponential and logarithmic equations respectively. A quantitative method is proposed to determine the hydraulic load cycle with maximum hydraulic load. The calculated result is 1.78 days flooding and 2.77 days drying, very similar with the test results.

Key words: rapid infiltration, hydraulic load, hydraulic load cycle, infiltration rate.

A New Way to Accelerate the Start-up of UASB Reac-