

浸没式平板膜生物反应器处理 工业区污水试验研究^{*}

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摘要 膜生物反应器(MBR)是膜技术和污水生物处理技术相结合的污水处理新工艺,近年来在城市污水和工业废水的处理中得到越来越多的关注。本试验采用浸没式平板膜生物反应器处理某城市工业区污水,并对该平板膜在运行过程中的膜污染情况进行试验研究,同时介绍其污水处理效果。试验表明,该MBR在次临界操作运行的情况下,以通量 $13\text{ L}/(\text{m}^2\cdot\text{h})$ 运行33 d后,膜污染非常严重,将平板膜取出清洗后改以 $8\text{ L}/(\text{m}^2\cdot\text{h})$ 恒流运行,在此后60多d运行时间内,MBR系统保持稳定。同时,系统对该工业区污水 COD_Cr 、 BOD_5 、 $\text{NH}_3\text{-N}$ 和浊度的平均去除率分别稳定在80%、95%、90%和98%以上,但对总氮的去除效果一般,去除率只有50%~60%。

关键词 膜生物反应器 临界通量 膜污染 污水处理

1 引言

膜生物反应器(MBR)是膜技术和污水生物处理技术相结合的污水处理新工艺,近年来已引起广泛的关注,并逐步应用于城市污水和工业废水的处理之中^[1~2]。由于传统生物处理技术二沉池固液分离性能的限制,使得反应器的微生物浓度不能太高,而MBR能成功代替二沉池进行高效固液分离,大大提高反应器的污泥浓度,同时具有出水水质好、耐冲击负荷强、污泥产率低等优点^[3,4]。

膜生物反应器一般可分为分置式膜生物反应器和浸没式膜生物反应器,而浸没式MBR将膜组件直接浸没于生物反应池中,利用曝气时气液向上的剪切力实现膜面的错流效果,从而有效控制膜污染。与分置式相比,浸没式MBR最大的特点是能耗较低^[5]。本研究采用浸没式平板膜生物反应器处理某城市工业区污水,并对该平板膜的运行性能及膜污染情况进行试验研究,同时介绍其污水处理效果。

2 试验装置和方法

2.1 试验工艺流程

试验工艺流程如图1所示,为强化脱氮效果,采用缺氧池-好氧膜生物反应器工艺。贮液罐内的污水经过进水泵提升进入反应器,通过进水槽的溢流和止回阀保证反应器内的水位恒定,溢流废水回流至贮液罐。进水经缺氧池自流进入好氧膜生物反应器内,通过出水泵对膜组件抽真空运行,真空表显示膜过滤操

作的压力,同时由回流泵进行内循环。

缺氧池和好氧膜生物反应器的有效容积分别为6 L和12 L,试验中控制内回流比为2,反应器内污泥浓度 $7\sim 8\text{ g/L}$,除了正常取样分析外,不排泥。试验采用的是一个平板膜式组件,膜材质为聚偏氟乙烯(PVDF),膜的有效过滤面积为 0.1 m^2 ,截留分子量100 kDa。运行时采取恒流操作,采用间歇抽停出水的方式(8 min开,2 min停),并控制曝气量为 $0.6\text{ m}^3/\text{h}$ 。

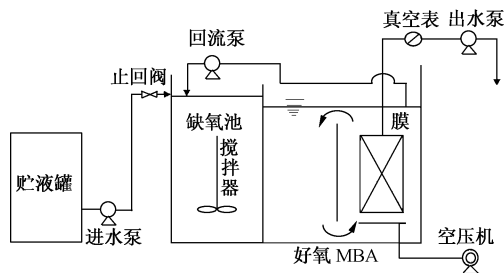


图1 试验工艺流程

2.2 废水特性

试验用水为某城市工业区污水处理厂沉砂池出水,其中工业废水和生活污水的比例约为1:1,具体废水特性如表1所示。由于该工业区内有众多的污染企业,包括染料厂、橡胶厂、电镀厂及石油化工企业等,其排放的废水中含有大量有毒有害物质,尽管在排入城市污水管网前已经过各个企业污水处理站的预处理,但仍然存在一部分难以降解的污染物质,加大了工业区废水处理的难度。

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表1 废水特性 mg/L(pH、浊度除外)

项目	COD _{Cr}	BOD ₅	pH	NH ₃ -N	总氮	SS	浊度/NTU
废水	150~560	60~240	6.9~8.5	19~40	28~55	200~300	80~260

3 结果和讨论

3.1 膜生物反应器的运行性能

不可避免的膜污染是限制该膜生物反应器长期稳定运行的主导因素,因此需要选择合适的操作运行条件以控制和减缓膜污染的产生和发展。临界通量在膜污染控制中是一个非常重要的概念,国内外众多研究表明次临界通量操作对维持MBR长期稳定运行有关键性作用^[6-8]。因此,在启动MBR运行前,有必要测定该平板膜在该试验操作条件(曝气量0.6 m³/h,污泥浓度8 g/L)下的临界通量。本研究采用通量阶梯式递增法对临界通量进行测量,结果如图2。

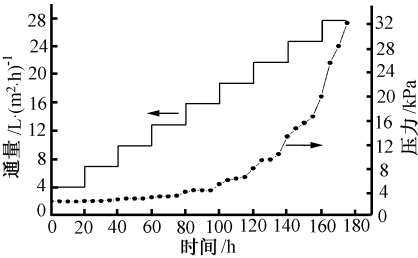


图2 临界通量的测定

由图2可知当运行通量不高于16 L/(m²·h)时,在20 min的连续抽吸间隔内操作压力能稳定为一个数值;而当通量高于19 L/(m²·h)时,操作压力随抽吸时间变化非常显著,尤其控制通量为28 L/(m²·h)时,操作压力急剧升高,导致系统迅速崩溃。因此,可认为该平板膜在上述操作条件下的临界通量为16~19 L/(m²·h)。

根据临界通量的测量结果,在同样的操作条件下,当膜通量低于16 L/(m²·h)时可视为次临界通量运行。图3为该MBR系统运行时操作压力随时间的变化关系。

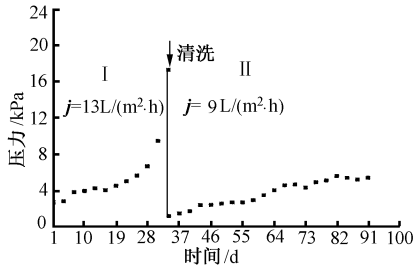


图3 操作压力随时间变化关系

由图3可知,该MBR以不同的通量恒流运行时呈现出不同的膜污染情况。在第一阶段,MBR以

13 L/(m²·h)运行,在最初20多d膜污染缓慢增长,但当操作压力达到6 kPa后,膜污染显著加剧,操作压力迅速变大,导致系统的崩溃。因此,在第33 d将膜组件取出清洗后,改以8 L/(m²·h)恒流运行。在此后2个月的运行时间内,MBR系统保持稳定,说明同样以次临界方式启动后恒流运行,选择较低的通量能减少膜清洗的频率和提高系统的稳定性。

3.2 污水处理效果

3.2.1 COD_{Cr}和BOD₅

该MBR的进水、上清液和出水的COD_{Cr}随时间的变化关系如图4所示。同时,图5表示MBR反应器上清液和膜出水的COD_{Cr}去除效率。

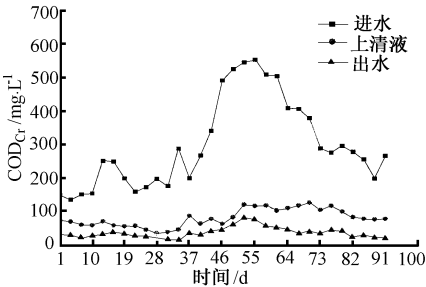


图4 COD_{Cr}随时间变化关系

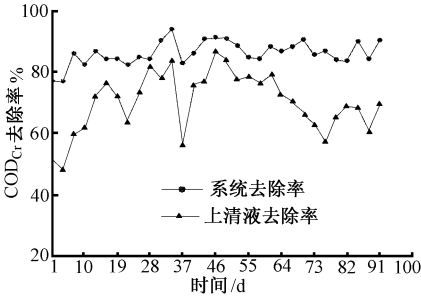


图5 COD_{Cr}去除率随时间变化关系

由图4、5可知,尽管进水COD_{Cr}波动很大,从150~560 mg/L,但系统去除率一直很高,稳定在80%~90%,绝大部分膜出水的COD_{Cr}都低于50 mg/L。另外,由上清液COD_{Cr}的变化趋势可以看出,依靠反应器内微生物的作用降解了绝大部分的污染物质,但随着进水COD_{Cr}的波动,上清液COD_{Cr}并不是非常稳定,在50~120 mg/L内变化。因此,平板膜在保证具有良好的出水水质和高去除率方面有着非常重要的作用。

同时,本试验对系统进出水的BOD₅进行检测分析。在3个月的试验期间,尽管进水的BOD₅在60~240 mg/L内波动,但膜出水的BOD₅非常稳定,平均去除率达到95%以上。这可能是由于平板膜的固液分

离作用使得MBR系统能保持较高的污泥浓度(在本试验中为8 000 mg/L左右), 即使遇到进水BOD₅急剧变化, 但系统的有机负荷F/M仍然维持在一个较低的水平, 这就保证了稳定的处理效果。

3.2.2 NH₃-N和总氮

图6为系统进出水NH₃-N浓度及去除率随时间的变化关系。由图可知, 该MBR对NH₃-N的去除效果非常好, 平均去除率达到90%。尽管进水NH₃-N浓度从19 mg/L波动到40 mg/L, 但去除率一直维持在一个很高的水平, 膜出水的NH₃-N平均浓度仅为2.5 mg/L, 这可能也是由于混合液保持较高的微生物量, 增强了系统的抗冲击负荷能力。

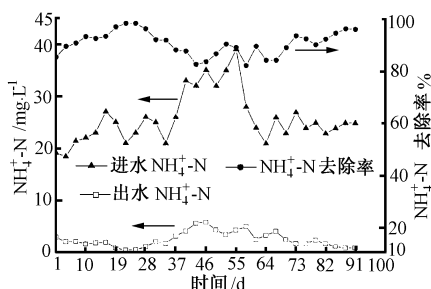


图6 进出水NH₃-N浓度及去除率随时间变化关系

另外, 在试验期间对进出水的总氮进行检测分析, 发现当进水的总氮浓度在28~55 mg/L波动时, 出水浓度为12~26 mg/L, 平均去除率仅为50%~60%左右, 效果并不是很好。由于该工业区污水含有一部分难降解物质, 进水的B/C比为0.4~0.5, 比一般城市生活污水要低, 而进水的总氮浓度却较高, 导致该污水的平均BOD₅/TN比仅为3~4, 所以在没有外加碳源的情况下, 反硝化效果不是很好。

3.2.3 浊度

在整个试验期间, 进水浊度很大, 变化范围为80~260 NTU, 但由于平板膜的高效固液分离特性以及混合液中微生物对污染物质的高效降解作用, 使得出水浊度稳定在5 NTU以下, 平均去除率达到98%以上。

4 结论

(1) 该聚偏氟乙烯(PVDF)平板膜在一定的操作条件(曝气量0.6 m³/h, 污泥浓度8 g/L)下, 临界通量为16~19 L/(m²·h)。

(2) MBR反应器在次临界通量运行的情况下, 以13 L/(m³·h)恒流运行1个月后, 系统崩溃, 将平板膜取出清洗后改以8 L/(m²·h)恒流运行, 在此后2个月的运行时间内, MBR系统保持稳定。

(3) MBR系统对该工业区污水COD_{Cr}、BOD₅、NH₃-N和浊度的平均去除率分别稳定在80%、95%、90%和98%以上, 但对总氮的去除效果一般, 去除率只有50%~60%。

(5) 平板膜在保证出水水质良好和去除率的稳定性方面起着非常重要的作用。

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ENGINEERING APPLICATION OF BIOFILTER-ACTIVATED SLUDGE PROCESS IN TREATMENT OF GAS-WASHED WASTEWATER FROM BIOMASS GASIFIER

Zhang Wenhua et al (7)

Abstract The application of treating gas-washed wastewater from biomass gasifier by a combined system is presented. This system is combined biofilter with activated sludge pool, and treatment of this wastewater by A-SBR-O and A-O_F-O₂ methods is investigated. COD_{Cr} removal rate of 85.4% and average NH₄⁺-N removal rate of 33.5% are obtained. This system can remove the COD_{Cr} efficiently by A-O_F-O₂ method, with average COD_{Cr} removal rate of 78.2% and average NH₄⁺-N removal rate of 22.7%.

Keywords biofilter, activated sludge, biomass gasification, gas-washed wastewater and water treatment

STUDY ON TREATMENT OF ACTIVATED DYE WASTEWATER BY CONTACT FLOCCULATION AND OXIDATION PROCESS

Wu Yongqiang et al (10)

Abstract Contact flocculation and oxidation process is employed for treating activated dye wastewater. This process features good treatment effect, less sludge and low cost etc. Experimental results indicate that over 90% COD_{Cr} and chroma can be removed by this process. The factors affecting the removal rate are also discussed. This result can basically meet the standard.

Keywords contact flocculation, oxidation, activated dye wastewater and unique water purification agent

TREATMENT OF INDUSTRIAL PARK WASTEWATER USING A SUBMERGED FLAT-SHEET MEMBRANE BIOREACTOR

Huang Shengsan et al (13)

Abstract Membrane bioreactors (MBRs), in which membranes are applied to biological wastewater treatment, have been greatly developed both in the treatment of domestic and industrial wastewater recently. A submerged flat-sheet membrane bioreactor was used for the treatment of industrial park wastewater in a city. The aims of this study were to investigate the changes in membrane fouling in the operation of a flat-sheet membrane bioreactor and also the treatment efficiency was given. Experiment results showed that membrane fouling was serious when the MBR operating at flux 13 l/(m²·h) for about 33 days, but increasing slowly during 2 months operation at flux 8 l/(m²·h). The removal efficiency of COD_{Cr}, BOD₅, NH₃-N and turbidity was 80%, 95%, 90% and 98% respectively, but the removal rate of total nitrogen was only 50% ~ 60%.

Keywords membrane bioreactor (MBR), critical flux, membrane fouling and wastewater treatment

TREATMENT OF WASTEWATER FROM PRODUCTION OF PRIMARY ETHYL CHRYSANTHEMATE

Ke Hong et al (16)

Abstract The waste water from production of primary ethyl chrysanthemate was treated using a process of "Fenton reaction-aerobic biological contact oxidation". The design parameters of treating units were determined. The removal efficiency of COD_{Cr}, nitrobenzene and aniline by the process was 94%, 78% and 83% respectively and the effluent quality after treating can meet the second-order of "The Comprehensive Wastewater Emission Standard" (GB8978-1996). The actual running effect was steady, the running cost was moderate and the engineering investment was reasonable.

Keywords wastewater from production of primary ethyl chrysanthemate, Fenton reaction and aerobic biological contact oxidation

TREATMENT OF WASTEWATER FROM A CHEMICAL PLANT BY INTERNAL ELECTROLYTIC REDUCTION-HIGH EFFICIENCY ANAEROBIC PROCESS

Sheng Qiaolian (18)

Abstract The wastewater from a chemical production plant contaminated with high concentration of organic matter, whose composition is complex. It is difficult to meet the discharge standard using conventional treatment processes. Our process employed multistage treatment method is used. First catalytic oxidation and fine iron powder internal electrolytic reduction reactor are used to reduce the concentration of organic matter in the wastewater and increase biodegradability of the wastewater. Then the wastewater inside the high-performance anaerobic reactor is further treated. This method provides high efficiency of organic matter removal. The quality of the treated water is stable and meets the wastewater discharge standard.

Keywords internal electrolysis, reduction, high-performance anaerobic reaction and chemical wastewater

PILOT-SCALE STUDY ON TREATMENT OF MIXED WASTEWATER OF VISCOSE FIBER

Lin Yan et al (20)

Abstract Mixed wastewater of viscose fiber is treated with cyclic activated sludge system and coagulation; the influences of organic load, periods, the types and dose of coagulant on the removal efficiency are investigated. The results show that the removal efficiency of COD_{Cr}, BOD₅, chroma can reach 95%, 96%, 95% respectively, and the effluent can meet the first-order of "The National Wastewater Discharge Standard" (GB8978-1996).

Keywords viscose fiber, wastewater, CASS and coagulation

STUDY ON THE PURIFICATION EFFICIENCY OF ARTIFICIAL CORRIDOR SYSTEM IN THE MICRO POLLUTED RIVER WATER

Chen Xiaohua et al (23)