

膜分离技术在给水和中水处理中的应用前景

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摘要: 介绍了膜分离技术的基本原理、发展和应用状况, 分析了微滤膜、超滤膜、纳滤膜和反渗透膜的特点, 及在给水和中水处理中的应用。最后列举了膜法水处理厂的实例, 分析了膜分离技术的发展动态。

关键词: 给水; 膜分离; 中水处理; 应用

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膜分离技术研究是从 20 世纪 30 年代开始, 60 年代起在商业上得到应用的。因其无相变、高效、节能、工艺和设备简单等特点, 膜分离技术在解决缺水、污水净化及水资源可持续利用等方面起着不可替代的重要作用, 得到工业发达国家的普遍重视, 发展十分迅速。目前, 已形成微滤、超滤、纳滤、电渗析和反渗透等多种系列产品。这些产品在化工、电子、轻工、纺织、冶金、食品、医药和医疗、石油化工等领域有广泛应用, 被誉为“21 世纪的水处理技术”, 在给水处理和中水处理领域中具有广阔的应用前景。

1 膜分离技术简介

1.1 基本原理

膜分离技术在水处理中应用的基本原理是: 利用水溶液(原水)中的水分子具有透过分离膜的能力, 在外力作用下对水溶液(原水)与溶质或其他杂质进行分离, 获得纯净的水, 从而达到提高水质的目的。

膜分离技术属于物理分离, 不发生相变, 故能量转化率高、分离效率高、节能效果好、操作简单、易于实现自动化。这是一种很有前途的新兴水处理技术。

1.2 膜的种类

在给水和中水处理领域, 滤膜按孔径大小可分为 4 类。不同的膜分离有着不同的分离机理和适用范围。各种膜分离过程及其特点如下:

1) 微滤膜(MF)。分离目的是溶液和气体脱粒子。膜的孔径范围为 $0.1\sim 0.2\ \mu\text{m}$, 透过组分是溶液和气体, 截留组分是 $0.02\sim 10\ \mu\text{m}$ 的粒子, 透过组分主要是料液中含的大量溶剂及少量的小分子、大分子溶质。过滤驱动压力差约 100 kPa, 分离机理是机械筛分, 属多孔膜类型, 特点是膜孔径均匀、空隙率高、过滤速度快、驱动压力低。

2) 超滤膜(UF)。分离目的是溶液脱大分子、大

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分子溶液脱小分子、大分子分极。膜的孔径范围为 $0.05\sim 0.1\ \mu\text{m}$, 透过组分是小分子溶液, 截留组分是 $1\sim 20\ \text{nm}$ 大分子溶质。透过组分主要是料液中含的大量溶剂和低价小分子溶质。过滤驱动压力差 $0.1\sim 1.0\ \text{MPa}$, 分离机理是机械筛分, 属非对称膜类型, 特点是驱动压力低, 但不能截留无机离子, 对水中氮和磷的去除率不高。

3) 纳滤膜(NF)。分离目的是溶液脱有机组分、脱高价离子, 软化、脱色、浓缩和分离。膜的孔径范围为 $0.5\sim 10\ \text{nm}$, 透过组分是溶剂、低价小分子溶质, 截留组分是 $>1\ \text{nm}$ 的溶质。过滤驱动压力差 $0.5\sim 1.5\ \text{MPa}$, 分离机理是溶解扩散 Donnan 效应, 属非对称膜或复合膜类型, 特点是对阴离子具有一定选择性, 能透过部分无机离子, 适用于给水处理。

4) 反渗透膜(RO)。分离目的是溶液脱溶质、含小分子溶质的溶液浓缩。膜的孔径范围为 $<1\ \text{nm}$, 透过组分是溶剂、可被电渗析截留组分, 截留组分是 $0.1\sim 10\ \text{nm}$ 小分子溶质。透过组分主要是料液中的大量溶剂。过滤驱动压力差 $1\sim 10\ \text{MPa}$, 分离机理是优先吸附毛细管流动、溶解~扩散, 属非对称膜或复合膜类型, 特点是透水性好、脱盐率高、对入流水质要求也高、所需驱动压差大。

滤膜材料包括各种有机高分子材料和无机材料。膜组件包括平板式、管式、卷式和中空纤维式。膜过滤系统可分为压力式与浸没式两种。

2 膜分离技术在给水和中水领域的应用

目前, 膜分离技术在给水处理和中水处理中的主要研究和应用领域为饮用水深度净化、优质工业用水制备和水的回用等方面。

反渗透膜的运行能耗大, 且过滤过程中去除了对人体有益的无机离子, 长期饮用这种高纯水会影响人体健康, 因此, 仅适用于海水和苦咸水的淡化处理和

废水回用处理。

纳滤膜对水中盐类的去除率在 50%~70%，对 3 价离子（如钙、镁等离子）去除率高达 95%，适用于硬度和有机物高、浊度低的原水。

超滤膜运行压力低，在去除水中绝大多数有害物质的同时可保留对人体有益的微量元素，不仅适用于地下水处理，也适合地表水处理。因此，从供水的卫生安全性和健康饮用水要求的角度考虑，超滤膜的可靠性好，适用于生活饮用水的深度处理，也适用于废水的回用处理。

微滤膜只能去除水中较大颗粒的物质，多用于纳滤和反渗透过滤的前置预过滤处理。

3 膜法水处理厂实例

目前，国内外已有多座在建和已运行的大规模膜法水处理厂。

1) 给水专项处理。苏格兰东、北、西苏格兰水务局的纳滤除色水处理厂，英格兰约克夏水务的超滤除隐孢子虫和贾第鞭毛虫水处理厂，澳大利亚维多利亚市和本迪戈市的微滤工艺处理生活饮用水厂，荷兰阿姆斯特丹市微滤除磷和除铁水处理厂。

2) 给水深度处理。北京奥运村超滤 / 纳滤直水处理，杭州南星桥水厂超滤深度处理，英格兰 Anglian 水务公司超滤 / 反渗透高级水处理厂。

3) 海水和苦咸水淡化处理。青岛海水反渗透淡化处理厂，新加坡海水反渗透淡化处理厂，英国泽西岛海水反渗透淡化处理厂，科威特海水和苦咸水反渗透淡化处理厂。

4) 滤池反冲洗回用处理。上海金海水厂过滤初滤水和反冲洗水微滤膜法回用处理，德国 Hittfeld 饮用水处理厂过滤反冲洗水膜法回用处理。

5) 污水再生回用处理。青岛污水尾水超滤回用处理厂，大连开发区污水尾水超滤回用处理厂，英国伦敦世纪穹顶超滤 / 反渗透回用水处理厂，墨西哥石化炼油厂废水反渗透膜回用处理用于离子交换软化器的进水，美国加利福尼亚发电厂废水反渗透膜回用处理用于生产软化水，英格兰西部冶炼厂废水反渗透膜回用处理用于生产软化水。

4 膜分离技术的发展动态

膜分离技术具有巨大的市场前景。膜分离产业在全球保持了超过 30% 的增长率，在我国也有着相当广阔的应用前景。

我国的膜分离技术从 20 世纪 60 年代中期起步研究，长期在实验室内和中试规模徘徊。膜工业近 10 年来得到较快发展，一直保持 20% 以上的市场增长率；而近几年膜的应用步伐也更加快，主要是随着膜材料的研究进展，膜材料的性能越来越好、寿命越来越长、成本也越来越低。另外，人们对膜的认识和技术的掌握有了很大的提高。随着国家能源政策和产业政策的逐步调整，我国在给水和中水回用处理上还有很广阔的发展空间，将会促进膜法水处理技术更快地发展。

5 结语

膜分离技术作为一门新兴的分离技术各个领域得到了广泛的应用。它是未来水处理的发展方向之一，应用于给水和中水处理，不但处理效果良好，还可回收利用再生材料，产生可观的经济效益和环境效益。

膜分离技术目前存在的问题主要是膜污染以及膜材料价格偏高，使用寿命相对较短。随着膜分离技术的发展，各种新型膜材料的问世，这些问题都将会得到解决，膜分离技术在水处理领域将会发挥越来越大的作用。

关于发布国家标准《工业建筑可靠性鉴定标准》的公告

中华人民共和国住房和城乡建设部公告第 157 号

中华人民共和国住房和城乡建设部

现批准《工业建筑可靠性鉴定标准》为国家标准，编号为 GB50144-2008，自 2009 年 5 月 1 日起实施。其中，第 3.1.1（1）、6.2.1、6.2.2、6.2.3、6.3.1、6.3.3、6.4.1、6.4.2、6.4.3 条（款）为强制性条文，必须严格执行。原《工业厂房可靠性鉴定标准》GB50144-90 同时废止。

本标准由我部标准定额研究所组织中国计划出版社出版发行。

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design

On Design of Ulan Bator Recycled Water Treatment Works in Mongolia

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Abstract: Introduced hereby is the project of Ulan Bator Recycled Water Treatment Works in Mongolia. Based on the quality of tail water from the sewage treatment works and different criteria and requirements of water quality for different purposes, the process for treatment of the recycled water is determined, with emphasis laid on the process of the treatment, and the parameters and characteristics thereof.

Key words: recycled water treatment;
engineering design;
water quality; treatment process;
aerated bio-filter tank

Studies on 3D Computer Modeling for Horizontal Flow Sediment Tank in the Sewage Treatment Works

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Abstract: To optimize the design of the horizontal flow sediment tank in No.2 Zhuyuan Sewage Treatment Works, the latest technique of numerical simulation is adopted to establish a 3D model for the design, and based on the process condition of the sediment tank, the typical operation condition is simulated, and, to ensure reliability of the results from simulation, they are verified with the data obtained from the site of a tank structured similar to the original design. With the results from simulation of different operation conditions, the original design is appraised of the 3D flow field and distribution of granular field in the sediment tank, including the outlet SS and curves for variation in sludge concentration, and the hydraulic status of the tank is predicted as the base for further optimization.

Key words: sewage treatment works;
computational fluid dynamics;
horizontal flow sediment tank;
numerical simulation;
3D flow field; appraisal

Process Design and Energy Saving of A Secondary Lift Pumping Station for Urban Water Supply

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Abstract: Introduced here are 3 ways commonly seen to booster the secondary lift pumping station. With examples of specific engineering design, the selection and installation of the booster pumps with the reservoir are illustrated, including the process pipeline layout and ways of disinfection. It is also pointed out that attention must be paid to protection against the water hammer and measures for energy saving during the design of the lift pumping station.

Key words: lift pumping station;
pipeline booster pump;
reservoir booster pump;
protection against water hammer;
energy saving

The Prospect of Membrane Separation Technique Applied to Treatment for Supplied Water and Recycled Water

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Abstract: Introduced hereby is the basic mechanism development and application of the membrane separation technique, with the analysis of features of the microfiltration, ultrafiltration, nanofiltration membrane and reverse osmosis membranes, and their application to treatment for supplied water and recycled water. Finally, some examples are given of the membrane water treatment works and its development.

Key words: water supply;
membrane separation;
recycled water treatment;

application

Key Techniques in Design of Nanhui Branch Works in the Raw Water Project at Qingcaosha Water Source in Shanghai

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Abstract: The Raw Water Project at Qingcaosha Water Source is a huge convey system of raw water, and Nanhui Branch Works is a component, covering a lift pumping station of 880 000 m³/d and the water conveyer of about 90 km in total length, DN2000~ DN1000 in diameter. The design of the lift pumping station on Nanhui Branch Works is optimized generally in the proposed system, valve fixed at the pump outlet, proposed adjustment of pumps, determination of the number of variable frequency pumps and analysis of the water hammer of the station, making the whole system more rational technically and economically. Simulation study is done with the computer which is a good reference for optimized design and operation management.

Key words: raw water project;
Nanhui Branch; water hammer;
variable frequency; Qingcaosha

An Approach to Energy Saving in Tunnel Ventilation Design

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Abstract: Based on the selection of ways of ventilation, and calculation of the wind demand, etc. in the design, measures adoptable for energy saving are summed up, proposals are made for the use of the jet fan, variable frequency speed regulation for the axial flow fan, control of ventilation system, etc. and finally introduced is the energy saving design for the air purification system.

Key words: tunnel ventilation; energy saving;
jet fan; variable frequency speed
regulation

Key Points for Evacuation Safety in the Design of Underground Rail Transit Station against Hazard

HU Wei

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Abstract: The design of floors and stairways in between is of the greatest importance in the design of the underground station against hazard. In connection with the requirements and specifications for architecture, analysis is made of the relevant specification for the design of floors and stairways. Based on the analysis of design, the reasonable number and location of the floors and stairways in the rail transit station are given, with additional explanation of the required 6 min evacuation in the specification for the rail transit system, and a proposal for providing the staircase for emergent evacuation at the end of the platform.

Key words: rail transit; underground station;
evacuation safety;
width of stairway;
check of evacuation time

Deformation of the Underground

Diaphragm--Counter Analysis of Internal Force

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Abstract: Based on the horizontal deformation value of the diaphragm, the least square method is adopted for curve fitting to get its deformed bending line, the counter analysis is made of the internal force of the wall, so that the actual situation of the diaphragm performance can be judged out. A comparison of the counter calculated bending and the actually measured one shows that they vary to the same rule and trend, which can be the base for optimization of design and adjustment of construction parameters.

Key words: foundation pit with support
structure;
underground diaphragm;
fitting of bending line;
internal force of moment