

膜技术助力非常规水资源开发利用

Membrane Technology facilitates the Development
and Utilization of Unconventional Water Resources

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2023年9月14日
Sep 14th, 2023

股票名称Stock name: 津膜科技
股票代码Stock numbe: 300334

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膜技术在非常规水资源处理中的 研究与应用

Research and Application of Membrane Technology in
Unconventional Water Treatment

非常规水资源

Unconventional Water Resources

非常规水源通常包括再生水、淡化海水、苦咸水、矿井水和集蓄雨水等。

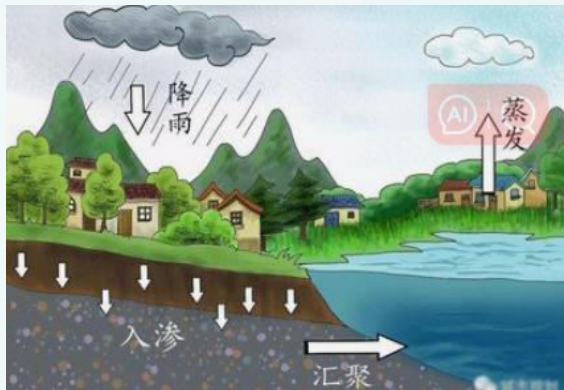
Unconventional water sources usually include reclaimed water, desalinated seawater, brackish water, mine water and rainwater harvesting.



再生水
Reclaimed water



海水
sea water



雨水
Rainwater



矿井水
Mine water



苦咸水
Brackish water

在压力驱动的水处理膜方面，分离膜一般按孔径范围分为微滤、超滤、纳滤与反渗透，不同膜的孔径分布不同，分离过滤机理与净化效果也不同。

In terms of pressure driven water treatment membrane, separation membrane technology is generally divided into microfiltration, ultrafiltration, nanofiltration and reverse osmosis based on the aperture range. Different membrane has different pore size distribution, different separation and filtration mechanism and different purification effect.

种类	孔径大小 单位: μm	被截留物	过滤对象	特点	应用场景	
液体膜	微滤	$>100,000$	<ul style="list-style-type: none"> 从气相和液相中截留微粒、细菌及其他污染物，可作为一般料液的澄清、过滤、空气除菌 	<ul style="list-style-type: none"> 过滤精度高、膜的厚度小以及吸附少、通量大、颗粒容纳量小及易堵塞 	<ul style="list-style-type: none"> 污/废水处理 工业特种分离领域 	
	超滤	10,000~100,000	<ul style="list-style-type: none"> 主要截留大分子（蛋白质、细菌）、胶体、悬浮固体等 	<ul style="list-style-type: none"> 物质不发生相变、适合于保味和热敏性物质、适用于不同分子量的分级处理 	<ul style="list-style-type: none"> 料液澄清 大分子有机物分离纯化 污水处理回用 海水淡化预处理等 	
	纳滤	0.001~0.003	200~1,000	<ul style="list-style-type: none"> 适用于对相对分子质量较小的物质，如无机盐或葡萄糖、蔗糖等小分子有机物进行分离 	<ul style="list-style-type: none"> 对不同价态的离子截留效果不同，并受离子半径影响、对蛋白质等物质有较强的抗污染性 	<ul style="list-style-type: none"> 料液浓缩 产品精制 水质净化等
	反渗透	0.0004~0.0006	>100	<ul style="list-style-type: none"> 可截留几乎所有的离子、有机物，也能够去除可溶性的金属盐、有机物、细菌等 	<ul style="list-style-type: none"> 分离效率高、杂质去除范围广、产水量大、生产成本低 	<ul style="list-style-type: none"> 纯净水 软化水 海水淡化 产品浓缩等

微滤膜技术 (Micro-filtration, MF)

- 孔径较大，操作压力低，水通量大，允许大分子和溶解性固体（无机盐）等通过，但会截留悬浮物，细菌，及大分子量胶体等物质。
- Large aperture, low operating pressure, large water flux, allowing macromolecules and dissolved solids (inorganic salts) to pass through, but it will trap suspended substances, bacteria, and large molecular weight colloids.
- 常用于对水质要求不高的再生水处理厂或作为纳滤膜与反渗透膜的预处理。
- It is often used in recycled water treatment plants with low water quality requirements or as pretreatment of

超滤膜技术 (Ultra-filtration, UF)

- 允许溶液中的溶剂（如水分子）、无机盐及小分子有机物透过，而将溶液中的悬浮物、胶体、蛋白质和微生物等大分子物质截留，从而达到净化和分离的目的。
- Allowing the solvent in the solution (such as water molecules), inorganic salts and small molecules of organic matter to pass through, and obtains the suspension of macromolecular substances such as colloids, proteins and microorganisms in the solution, so as to achieve the purpose of purification and separation.
- 超滤应用范围及其广泛，纯水、超纯水和海水淡化工艺中作为NF和RO的预处理，饮用水、矿泉水净化，工业废水与生活污水的净化和回收等。
- Having a wide range of applications, such as pretreatment of NF and RO membrane in pure water, ultra-pure water and seawater desalination processes, purification of drinking water, mineral water, purification and recovery of industrial wastewater and domestic sewage, etc.

纳滤膜技术 (Nano-filtration, NF)

- 一种新型分子级膜分离技术，对溶质的截留性能介于RO与UF膜之间，对特定的溶质具有高脱除率，能够去除二价、三价离子。
- The novel molecule-level membrane separation technology has a solute retention performance between RO and UF membranes with a high removal rate for specific solutes, and divalent and trivalent ions can be removed.
- 主要应用于脱盐浓缩、染料分离及其废水处理，中水回用，海水淡化等。
- Mainly used in desalting concentration, dye separation and its wastewater treatment, water reuse, seawater desalination and so on.

反渗透膜技术 (Reverse-osmosis, RO)

- 一种以压力为推动力的膜分离过程，属于无孔致密膜，能够去除水中的无机离子与有机物。
- A pressure-driven membrane separation process, belonging to a non-porous dense membrane, capable of removing inorganic ions and organic matter in water.
- 反渗透在水处理中的应用也较为广泛，如常规水处理净化、城市污水深度处理、含油含重金属等的废水处理、海水淡化等。
- Reverse osmosis is also widely used in water treatment, such as conventional water treatment and purification, advanced treatment of urban sewage, wastewater treatment containing oil and heavy metals, and seawater desalination.

政策鼓励膜产业快速发展

Policies encourage the rapid development of membrane industry



“十二五”期间将膜产业认定为战略性新兴产业。

- “十三五”期间明确了高性能分离膜材料作为关键战略材料的发展重点，其中高性能分离膜材料被列入关键性战略材料。
- “十四五”提出，加快推动绿色低碳发展，发展环保产业，持续改善环境质量；发展战略性新兴产业，加快壮大新材料、高端装备、绿色环保等产业，培育新技术、新产品、新业态、新模式。
- 各部委陆续出台了“十四五”城镇污水处理及资

源化利用发展规划、“十四五”节水型社会建设

规划、海水淡化利用发展行动计划2021-2025

During the “12th Five-Year Plan” period, the membrane industry was identified as a strategic emerging industry.

During the “13th Five-Year Plan” period, the development focus of high-performance separated membrane materials as a key strategic material was clarified, and high-performance separated membrane materials were included in the key strategic materials.

The “14th Five-Year Plan” proposes to accelerate the promotion of green and low-carbon development, develop environmental protection industries, continuously improve environmental quality, develop strategic emerging industries, accelerate the expansion of new materials, high-end equipment, green environmental protection and other industries, and cultivate new technologies, new products, new business forms and new models.

Ministries and commissions have successively issued the “14th Five-Year “Urban sewage Treatment and resource Utilization Development Plan, the “14th Five-Year” water-saving Society Construction Plan, the Seawater Desalination Utilization Development Action Plan 2021-2025, the “14th Five-Year” Industrial Green Development Plan, and the industrial water efficiency Improvement Action Plan.

膜技术的优势 Advantages of Membrane Technology

膜分离技术具有处理效率高、节能、出水水质优、适用范围广和工艺简单稳定、易于实现自动化等优点，在非常规水资源处理中的应用具有显著优势。

Membrane separation technology has the advantages of high treatment efficiency, energy saving, excellent permeate quality, wide application range, simple and stable process, easy to realize automation, etc., and has significant advantages in the application of unconventional water resources treatment

充分开发多样性的非常规水源

Full exploitation of diverse unconventional water sources

- 单一膜技术或多膜集成技术能够满足不同水源、水质的处理与回用，为不同类型非常规水源的资源化利用提供了可能
- Single membrane technology or multi-membrane integration technology can meet the requirements for the treatment and reuse of different water sources and water quality, and provide the possibility for the resource utilization of different types of unconventional water sources.

提高水的利用效率

Improvement of the efficiency of water use

- 膜技术的易集成和高效的特点，使其能够应用于不同领域，有助于实现废水的循环利用，减少了废水的排放
- The easy integration and high efficiency of membrane technology enable it to be applied in different fields, which helps to realize the recycling of wastewater and reduce the discharge of wastewater.

技术节能降低成本

Technical energy conservation to reduce costs

- 技术节能的特点能有效降低非常规水源开发和利用的成本,尤其是反渗透技术在海水淡化、苦咸水淡化和污水资源化方面已经取得突破性进展
- The characteristics of technical energy saving can effectively reduce the cost of unconventional water source development and utilization, especially the reverse osmosis technology has made breakthrough progress in seawater desalination, brackish water desalination and sewage resource recycling.



核心膜产品与技术 Core Membrane Products and Technologies



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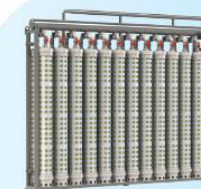
连续膜过滤



膜生物反应器

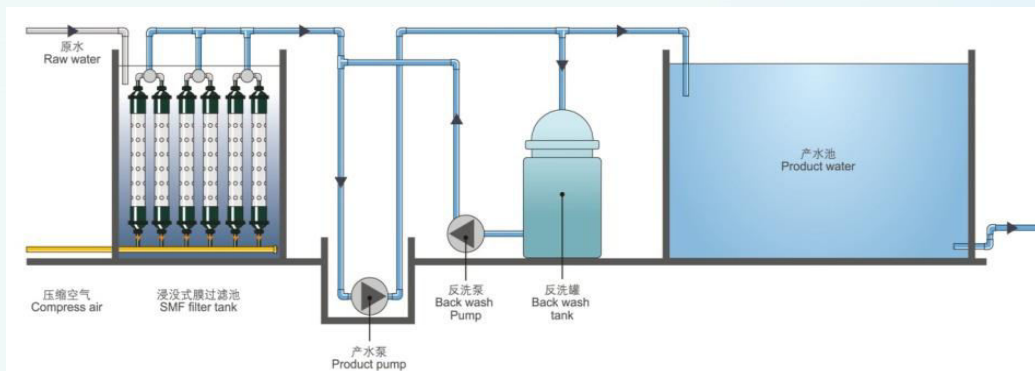
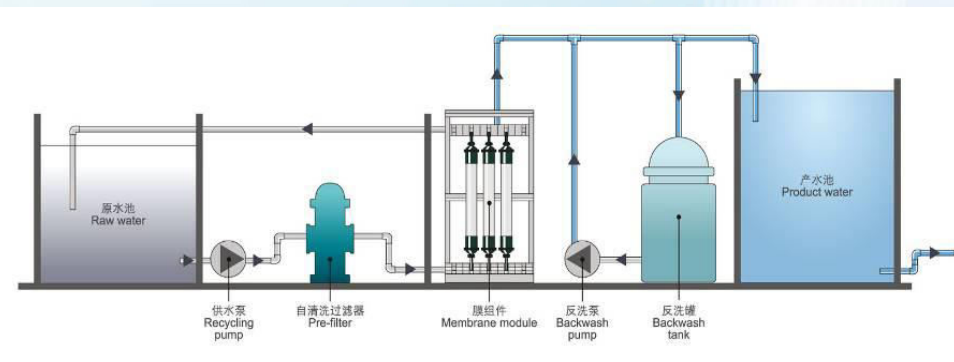


一体化(MBR)污水设备



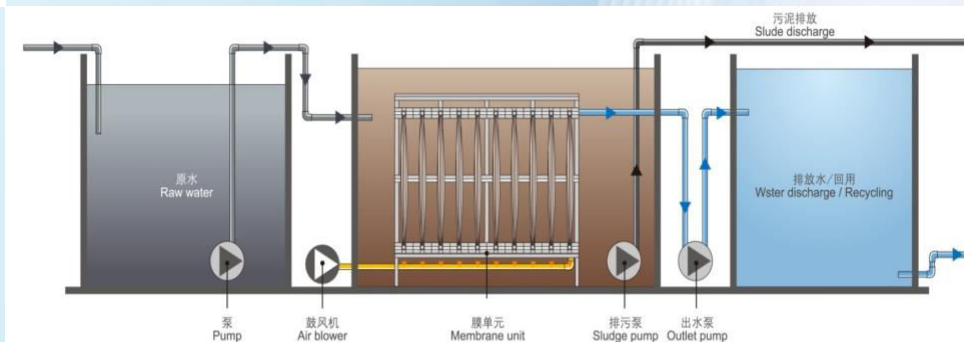
浸没式膜过滤

压力式连续膜过滤技术 (CMF)



浸没式连续膜过滤技术 (SMF)

膜生物反应器技术 (MBR)



在研新产品&新技术

New research and development products and technologies

改性PVDF膜材料

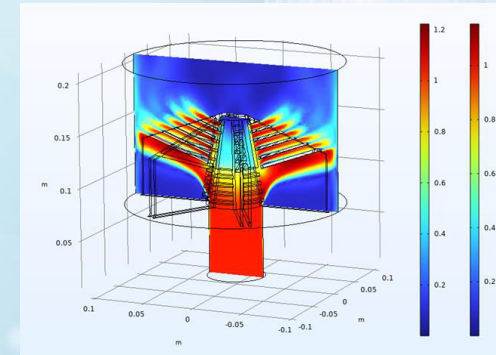
Improved PVDF membrane material

脉冲曝气MBR膜组件 MBR Siphon Aerator technology (Pulsed Aeration)



双端产水膜组件

*Double-ended water
producing membrane*



再生水应用 Reclaimed water application

工艺 Process	SMF+RO
地点 Place	天津张贵庄
原水 Raw water	一级A达标水
规模 Scale	6万吨/日
投运 Operation Date	2013.05
用途 Permeate used	电厂冷却用水



再生水应用 Reclaimed water application

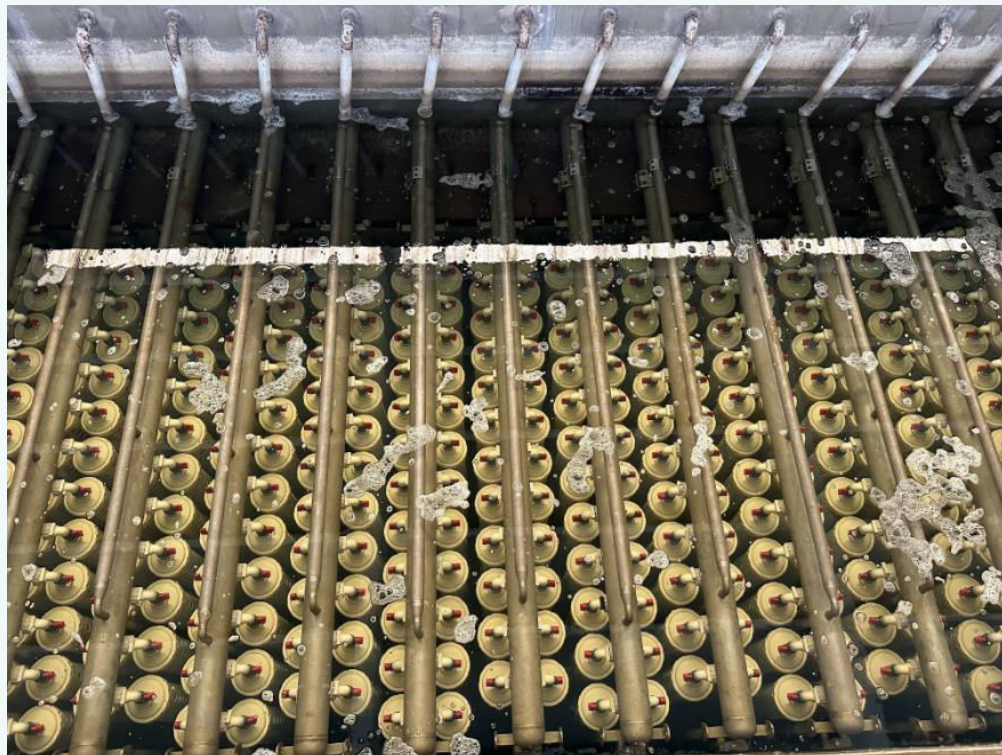


工艺 Process	SMF+RO
地点 Place	天津津沽
原水 Raw water	市政污水
规模 Scale	8万吨/日
投运 Operation Date	2014.9
用途 Permeate used	锅炉补给水

工艺 Process	CMF+RO
地点 Place	泰达新水源
原水 Raw water	市政污水、工业污水
规模 Scale	4万吨/日
投运 Operation Date	2017.12
用途 Permeate used	中水回用



再生水应用 Reclaimed water application



工艺 Process	SMF+RO
地点 Place	北塘
原水 Raw water	市政污水
规模 Scale	4.5万吨/日
投运 Operation Date	2012.4
用途 Permeate used	中水回用

再生水应用 Reclaimed water application

工艺 Process	MBR
地点 Place	甘肃张掖
原水 Raw water	市政污水
规模 Scale	6万吨/日
投运 Operation Date	2019.12
用途 Permeate used	生产用水、达标排放





工艺 Process	MBR+RO
地点 Place	浙江
原水 Raw water	高盐印染废水
规模 Scale	1.5万吨/日
投运 Operation Date	2016年
用途 Permeate used	达标排放

再生水项目业绩（部分）

Partial reclaimed Water Project References

项目 Projects	原水 Raw water	处理规模(吨/天) Treatment capacity (m3/day)	采用工艺 Process
宁乡某污水处理厂	市政污水	150000	SMF+RO
天津某再生水厂迁建工程项目	市政污水	130000	SMF+RO
天津某再生水厂项目	市政污水	80000	SMF+RO
天津某再生水厂	市政污水	65000	SMF+RO
天津某再生水厂	市政污水	60000	SMF+RO
东营某污水处理厂	市政污水	50000	SMF+RO
天津某污水厂	市政污水	60000	SMF+RO
天津市天津某水业	市政污水	50000	CMF+RO
天津某再生水厂水厂	市政污水	50000	CMF+RO
甘肃某污水厂	市政污水	60000	MBR

海水淡化膜法工艺

Seawater desalination membrane process

广泛应用工艺：反渗透技术

Widely used process: reverse osmosis technology

优势：投资适中、效率高、工艺成熟

Advantages: moderate investment, high efficiency, mature technology

劣势：容易结垢以、产生膜污染

Disadvantages: easy to scale, resulting in membrane pollution

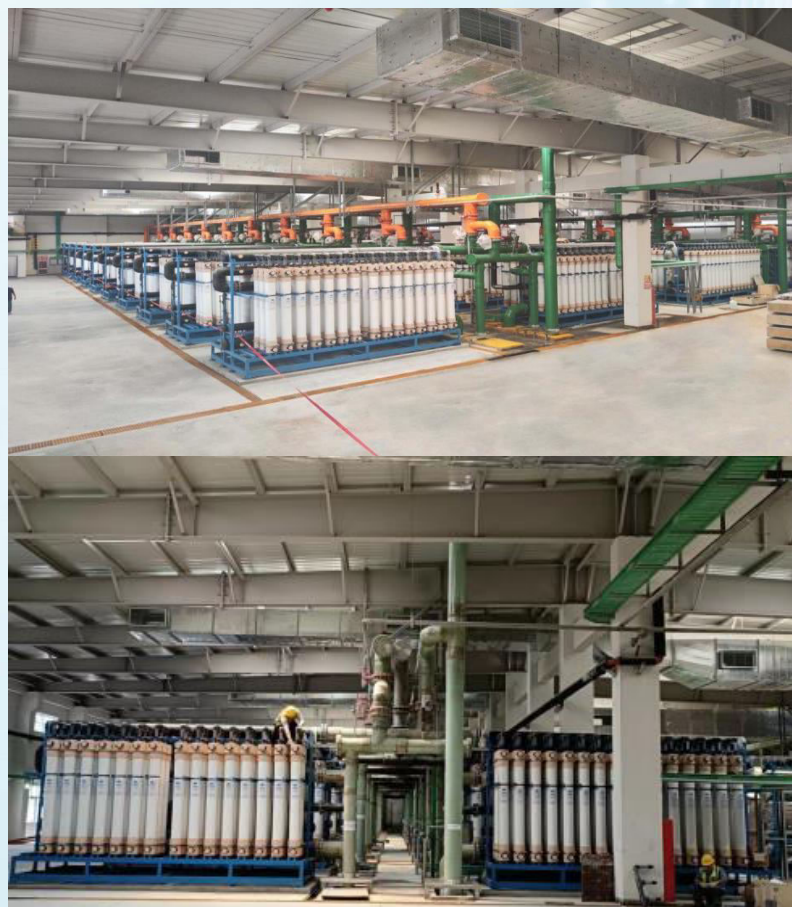


预处理极为重要：微滤、超滤和纳滤全膜法预处理

Pretreatment is extremely important: full-membrane pretreatment with microfiltration, ultrafiltration and nanofiltration

海水淡化应用 Seawater desalination application

工艺 Process	气浮+超滤+一级RO+二级RO
地点 Place	青岛
原水 Raw water	海水
规模 Scale	10万吨/日
投运 Operation Date	2021年
用途 Permeate used	生产用水、生态用水





工艺 Process	混凝沉淀+管道过滤器+超滤+ 一级RO+二级RO
地点 Place	三沙永兴岛
原水 Raw water	海水
规模 Scale	1000吨/日
投运 Operation Date	2017年
用途 Permeate used	生活用水

海水淡化应用 Seawater desalination application

工艺 Process	CMF+RO
地点 Place	山东
原水 Raw water	海水
规模 Scale	9万吨/日
投运 Operation Date	2015年
用途 Permeate used	精制卤水



工艺：超滤+反渗透 or 超滤+纳滤

Process: ultrafiltration + reverse osmosis or ultrafiltration + nanofiltration

- 苦咸水是指含盐量为1000~5000mg/L的水。
Brackish water refers to water with a salt content between 1000-5000mg/L.
- 反渗透和纳滤技术不断改进，已成为苦咸水淡化的首选技术。
Reverse osmosis and nanofiltration technologies have been improved and have become the preferred technologies for brackish water desalination.
- 水质相同时，纳滤苦咸水淡化较反渗透存在动力能耗低，设备投资低等优势。
Under the same water quality condition, nanofiltration brackish water desalination has the advantages of lower power consumption and equipment investment compared with reverse osmosis.

工艺：超滤+反渗透 or 超滤+纳滤

Process: ultrafiltration + reverse osmosis or ultrafiltration + nanofiltration

- 矿井水中含有大量的无机离子，硬度较高。

Mine water contains a large number of inorganic ions and with high hardness, so salt removal is very important

- 常用的膜技术有电渗析、反渗透和纳滤,其过程与海水、苦咸水淡化过程十分相似。

The commonly used membrane technologies are electrodialysis, reverse osmosis and nanofiltration, and the process is very similar to the desalination process of seawater and brackish water

- 纳滤膜技术将成为经济高效的一种处理工艺。

Nanofiltration membrane technology will become a cost-effective treatment process

未来水资源开发与膜技术趋势展望 Future Trends in Water Resources Development and Membrane Technology

未来水资源开发与膜技术趋势展望

Future Trends in Water Resources Development and Membrane Technology



津膜科技

水资源的供需矛盾愈加突出，非常规水源开发与利用对社会发展的支撑作用更加凸显

The contradiction between supply and demand of water resources is becoming more and more prominent, and the development and utilization of unconventional water sources are playing a more prominent role in supporting social development

根据水源状况针对性地制备高性能的膜和设计多膜过程集成工艺或开发膜与其他技术耦合的工艺是未来膜技术领域的重要研究方向

It is an important research direction in this field in the future to prepare high-performance membranes according to water conditions and design multi-membrane process integration processes or develop processes that couple membranes with other technologies.



我们的研究与发展方向

Our Research and Development direction

- 研制具有高分离性能、高化学稳定性、耐污染、低成本的新型膜材料。

To develop new membrane materials with high separation performance, high chemical stability, pollution resistance and low cost.

- 加强纳滤及反渗透的预处理技术，提高膜抗污损力和延长膜组件使用寿命，进而提高产水率，降低运行成本。

To strengthen the pretreatment technology of nanofiltration and reverse osmosis to improve the anti-fouling force of the membrane and prolong the service life of the membrane modules, thus increasing the water yield and reducing the operating cost.

- 加强脱盐系统运行稳定性，降低反渗透海水淡化技术运行费用。

To strengthen the stability of desalting system and reduce the operating cost of reverse osmosis desalination technology

- 纳滤具有高脱盐性和可脱除无机盐的性能，运行成本较反渗透低，是目前世界膜分离领域研究的热点之一，也是我们的重点研发方向。

As nanofiltration has the properties of high desalination and removal of inorganic salts, and its operating cost is lower than reverse osmosis. So it is one of the hotspots in the field of membrane separation research in the world, and it is also our key research and development direction.

感谢聆听！

Thanks for listening!