

An aerial photograph of a coal processing site, showing several large, shallow ponds of water interspersed among dark, rocky terrain. The image is framed by vertical blue decorative bars on the left and right sides.

## SALT RECOVERY AT A COAL TO CHEMICAL PLANT

### *Case study*

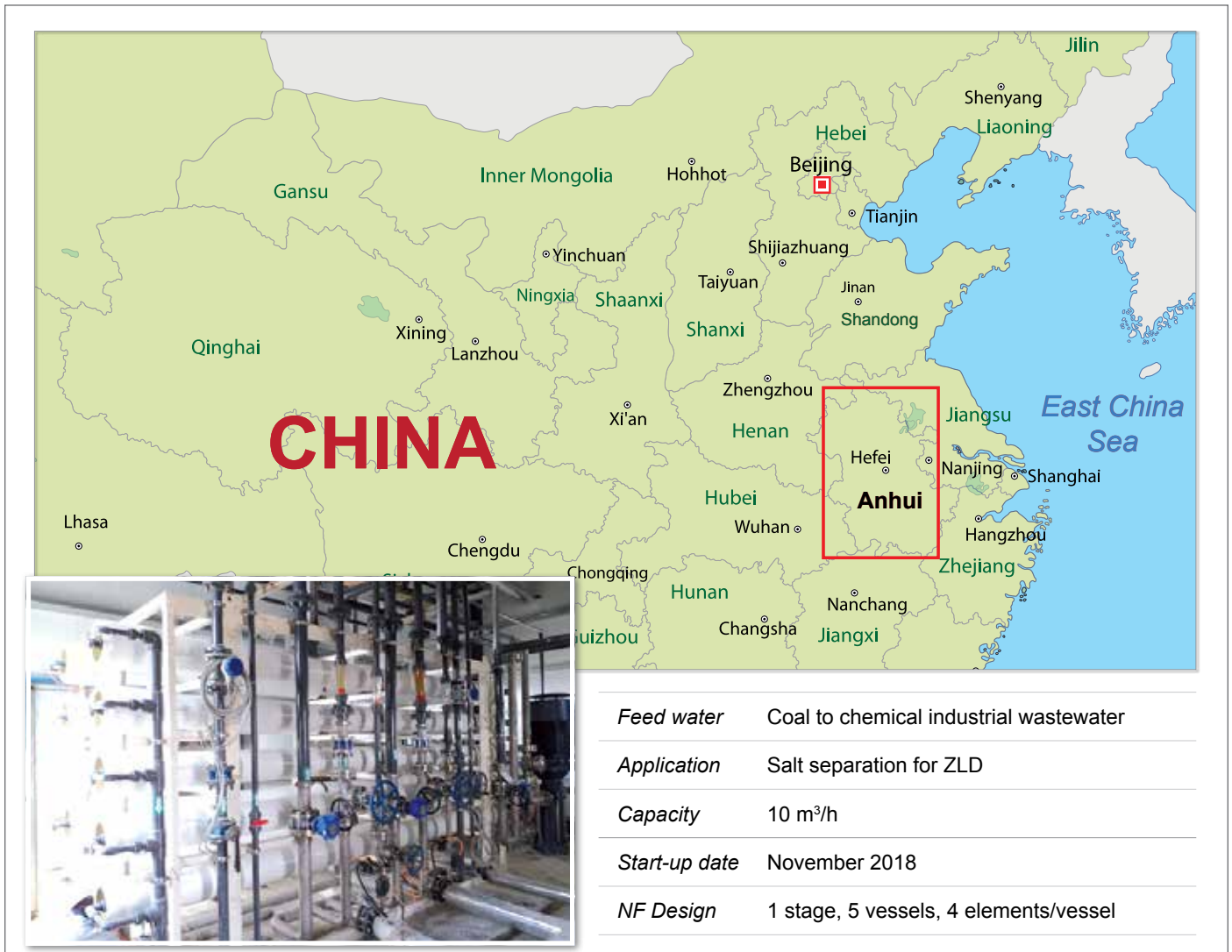
*Hydranautics' PRO-XS2 Nanofiltration (NF) membrane offers value proposition by recovering pure  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  salts at lower costs.*

The

## PROBLEM

A coal to chemical plant in Anhui province produces wastewater containing a mixed salt of  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$ . Because of Zero Liquid Discharge regulations, this stream needs to be treated, recycled and the salts recovered. This

process requires concentration of the stream, evaporation and crystallization that gives a mixed salt. But unfortunately, mixed salt is considered a solid waste not having any commercial value and requiring additional cost for disposal.



The

## SOLUTION

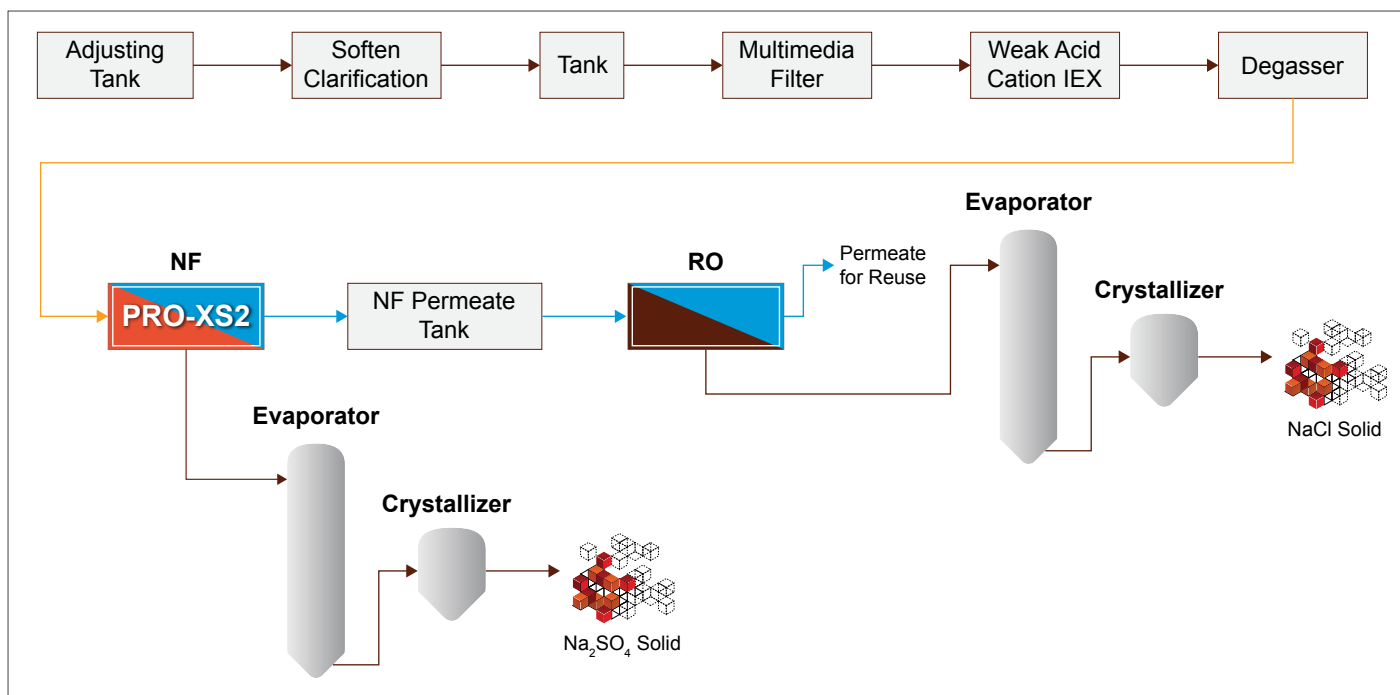
To improve economics of the treatment processes, Hydranautics recommended the client to use their highly selective NF membranes, PRO-XS2, for separating the  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  salts.

Using this process, purified  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  salts became by-products that could be reused as raw materials in the industry.

A treatment system was set up in the Anhui plant to treat waste stream at 15 m<sup>3</sup>/h flow. This system uses Hydranautics' highly selective NF membrane, PRO-XS2, primarily to separate  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  salts. The  $\text{NaCl}$  salt goes to the permeate side and the  $\text{Na}_2\text{SO}_4$  salt gets concentrated in the reject stream.

**PRO-XS2** is a polyamide spiral wound nanofiltration membrane. It is specifically designed for salt separation in the liquid stream to achieve more purified salt streams for either salt extraction or recycle. **PRO-XS2** is a brackish range operation pressure module.

**PRO-XS2** has a very high rejection on divalent anions. The highly selective nature of the membrane, resulting from a strong Donnan effect, can achieve very good separation of the mixed salt stream, and maintain good resistance on general organic and biological fouling.



Design paramaters	
Permeate flow	10 m <sup>3</sup> /h
Concentrate flow	5 m <sup>3</sup> /h
Concentrate recirculation	12 m <sup>3</sup> /h
Recovery	66.7%
Flux	13.4 lmh

Feed conditions	
Feed EC	31,300 – 59,000 µS/cm
Feed pH	8.2 – 9.2
Feed COD	380 – 770 mg/l
Feed pressure	1.0 – 2.4 MPa

The salt concentrations data was analysed by a third-party testing company. It showed that the ratio of SO<sub>4</sub>/Cl was 1.5 in the NF feed, only 0.02 in the NF permeate, and it increased to 5.9 in the reject stream. This means Na<sub>2</sub>SO<sub>4</sub> got concentrated in the reject whereas NaCl gets concentrated in the permeate. About 98.6% of SO<sub>4</sub><sup>2-</sup> ions were thus recovered in the reject stream.

Hydranautics' highly selective NF PRO-XS2 membrane model has high monovalent and divalent separation performance. It has a nominal MgSO<sub>4</sub> rejection of 99.7% at most concentrations.

At the same time, it allows higher Chloride passage through the membrane that increases Chloride concentration in permeate. Thus, PRO-XS2 achieves a good SO<sub>4</sub> and Cl separation.

Analytical Performance	Feed	Permeate	Concentrate	Rejection
Electrical Conductivity (µs/cm)	36,300	12,000	59,300	66.9%
Sodium, Na <sup>+</sup> (mg/l)	6,070	3,720	12,000	38.7%
Chloride, Cl <sup>-</sup> (mg/l)	6,310	7,560	5,050	-19.8%
Sulfate, SO <sub>4</sub> <sup>2-</sup> (mg/l)	9,380	127	29,800	98.6%
<b>Ratio of SO<sub>4</sub><sup>2-</sup>/Cl<sup>-</sup></b>	<b>1.49</b>	<b>0.02</b>	<b>5.9</b>	–

## The IMPACT

The superior SO<sub>4</sub> and Cl salt separation performance by Hydranautics' PRO-XS2 membrane resulted in cost savings for the Anhui coal to chemical plant.

The evaporator and crystallizer CAPEX and OPEX costs for NaCl reduced because it had to treat only 2/3<sup>rd</sup> of the initial flow. The reduced flow into the evaporator and crystallizer, helped reduce the thermal process plant size. In addition, the Na<sub>2</sub>SO<sub>4</sub> crystallizer CAPEX and OPEX also reduced considerably.

Another benefit was, unlike a mixed salt, Na<sub>2</sub>SO<sub>4</sub> and NaCl salts could be recovered in a pure state which had a commercial value and could be re-used in the industry. This protects the environment by reducing residual waste discharge liabilities.

The process of using Hydranautics' NF membranes has been gradually applied in coal-to-chemical ZLD projects in recent years, because of its relatively lower cost than traditional thermal salt separation processes.



*About the author*

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*Linda Xie is a Senior Technical Manager for Hydranautics serving the China region and has over 18 years experience in the field of membrane applications.*

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#### **About Hydranautics**

Since our founding in 1963, Hydranautics has been committed to the highest standards of technology research, product excellence and customer fulfillment. Hydranautics entered the Reverse Osmosis (RO) water treatment field in 1970 and is one of the most respected and experienced firms in the membrane separations industry. We joined the Osaka, Japan based Nitto Denko corporation in 1987 which was founded in 1918 and now has 117 companies in more than 20 countries, with over 30,000 employees worldwide. Our alliance with this global film industry giant boosts Hydranautics to a superior level of technological sophistication, product performance and customer response.

We are not simply product manufacturers; we are your membrane technology partners. As leaders of high quality membrane solutions, we believe our obligations extend beyond manufacturing and selling our products. Our skilled staff of technicians, engineers and service professionals assist in designing, operating and maintaining a robust, reliable and efficient membrane system to meet your requirements and exceed your expectations. Our support is offered from early stage conceptual design and engineering to start-up and maintenance, no matter the location globally whether it is on land or off-shore.

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