Operating Flexibility & Economics
Re-shape Electrodialysis Reversal

Historically, on the basis of capital cost and power consumption, electrodialysis (ED) technology has taken second place to reverse osmosis (RO) as a non-thermal desalination method for seawater. However, by taking a new direction, current ED(R) design is not only challenging this position but also making its mark in industrial water recovery from RO systems.

Precursors to the next EDR

Evoqua's electrodialysis was initially conceived as a low-energy alternative to thermal techniques for desalting seawater. It has since found a practical role in brackish water desalination, enabling industry authorities to utilize an otherwise untapped resource. In the 1970s, reverse osmosis found suitability in large-scale desalination plants, once commonly operated with thermal techniques, which can make use of waste heat from sites such as power plants and refineries. RO subsequently flourished in locations without a large source of 'free' heat. ED, originally introduced in the 1950s, competed with RO in brackish water desalting applications. With the advent of polarity reversal, EDR became more competitive with RO due to reduced pretreatment requirements (lessening the need for acid and antiscalant treatments).

New approach for changing times

In the past decade, two converging market trends prompted a review and remodeling of EDR, as a serious competitor to RO desalination. These were (a), a rising requirement to conserve and recycle water, both in potable and industrial applications, while reducing energy consumption and (b), a relative fall in the costs of automated valve technology, control systems and ED module construction. It was vital, in redesigning EDR equipment, to retain the existing features of the process and its intrinsic advantages over RO: low operating pressure; noiseless operation; no vibration; output tenability; operational flexibility; chlorine tolerance; and no exotic materials required for piping, valves, pumping, etc. The problem was how to bridge the gap to create an economic advantage. For Evoqua Water Technologies, advances made in the development of Ionpure continuous electrodeionization (CEDI) modules provided a platform to improve on existing EDR. Three key tasks were identified: to introduce a new membrane, a new module construction and a low energy process design.

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EDR breakthrough

The project that ultimately established a new EDR generation was a technology endeavor funded by the Singapore Environment and Water Industry Programme Office. In 2008, new energy saving capabilities were developed in the laboratory, which then led to Evoqua winning the government's 'Singapore Challenge'. The race was then for the company's US and Singapore R&D facilities to develop a commercial version of the process. By 2011 a 50m3/day pilot system showed that the new EDR desalination process could use half the energy of an equivalent RO plant. It was also shown to be tunable to required output salinities, or total dissolved solids (TDS) and to be quiet in operation, working at low pressure. The heart of this next-generation EDR module, named NEXED™, is an innovative membrane with a unique design. The membrane is superior to earlier ED technology in its electrical resistance, ion permselectivity (charge selectivity), and water transport allowance. The modular, cross-flow cell construction addresses an earlier limitation of ED, which is the incomplete utilization of membrane surface area. In NEXED™, the membrane performs ionic filtration across approximately 85 percent of the total area – an increase of up to 25 percent on existing devices.

A cost-driven design uses highly automated, modular cell construction and molded components. Coupled with the higher membrane performance and utilization, the result is reduced costs on all fronts: system, energy, lifecycle and footprint. Low-energy, low-pressure membranes and tunable dissolved solids (TDS) removal capability reduce energy expenditures and also minimize system maintenance. By adjusting input power, the module can manipulate output quality to meet changing application requirements, or to provide consistent water quality with variable feed water parameters.

Nexed EDR Module

RO reject recovery application

Although, through exhaustive testing, the new generation of EDR design is proven to deliver cost-effective desalination, the operational flexibility of the design also permits other applications, including RO reject recovery. Industries that require high-purity water such as semiconductor, pharmaceutical, food and beverage processing and power commonly use RO systems. They produce waste brackish reject streams with high salt concentrations that can be optimized to reduce water consumption and reduce disposal costs. Typically, RO systems only recover between 50 percent and 75 percent of water. The remainder is discharged as wastewater.

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While this could be fed directly into a second RO unit, the likelihood of scaling or fouling the second RO without pretreatment is high. This is not a problem for new generation EDR. A single module treats up to 12 m3/h (53 gpm) RO reject, while removing over 50 percent of total ionized solids. This enables up to 97 percent overall system water recovery and in comparison to a second RO stage, EDR is less susceptible to problems of silica scaling. ■

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تاريخيًا، احتلّت تقنية الفصل الغشائي الكهربائي المركز الثاني خلف تقنية التناضح العكسي باعتبارها وسيلة من وسائل تحلية المياه غير الحرارية، وذلك من جهة التكاليف الرأسمالية واستهلاك الطاقة. إلّا أنّه مع اتخاذه منحى جديدًا، لا يشكّل التصميم الحالي للفصل الغشائي الكهربائي العكسي تحديًا لهذا المركز وحسب، بل يترك بصمة في انتعاش قطاع المياه تختلف عن نظم التناضح العكسي. لقد اعتُبِر الفصل الغشائي الكهربائي "إيفوكا" (Evoqua) في البداية كبديلٍ موفّرٍ للطاقة يختلف عن التقنيات الحرارية المستخدمة في تحلية مياه البحر. وقد وجد منذ ذلك الحين دورًا له في عملية تحلية المياه. الأمر الذي أتاح لهيئات الصناعة من استخدام مورد آخر لم يستغله أحد. لقد تناسب اعتماد التناضح العكسي في السبعينات في محطات تحلية المياه ذات النطاق الواسع، وهي عادة كانت تعمل بالتقنيات الحرارية والتي بدورها كانت تستفيد من الحرارة الناتجة عن مواقع مثل محطات توليد الكهرباء ومصافي النفط. وازدهرت تقنية التناضح العكسي في ما بعد في مواقع تفتقر إلى مصدر كبير للحرارة "المجانية". وتمَّ إدخال تقنية الفصل الغشائي الكهربائي في الخمسينات. وتنافست مع تقنية التناضح العكسي في استخدامها لتحلية المياه. ومع ظهور القطبية العكسية، أصبح الفصل الغشائي الكهربائي العكسي أكثر قدرة على التنافس والتناضح العكسي نتيجة لانخفاض متطلبات المعالجة المسبقة.