ADVANCES IN SEA WATER REVERSE OSMOSIS (SWRO) AND EFFLUENT RECYCLE SYSTEMS

Ajay Popat
Chief Executive Officer
Ion Exchange Waterleau Ltd.

Abstract

Depleting supplies of fresh water, contamination of acquifers with pollutants from industrial discharge, tighter specifications for water for industrial and municipal use coupled with pressure from Pollution Control Board have compelled the industries to look for alternate and better methods of treating our water and waste water.

Since the development of cellulose acetate membranes by Dr. S. Sourirajan and Dr. S. Loeb for commercial applications in 1960, we have witnessed truly breath-taking advances in the field of SWRO and effluent recycle processes.

The paper attempts to highlight the current practices and advances in SWRO and effluent recycle processes. It will also present the basic working philosophy of new membrane processes that have recently been commercialized in India.

Relevant case histories will be presented during the conference by the author to support the contents of this paper.

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Ajay Popat
Vice President (Corporate Marketing)
Ion Exchange (India) Ltd.

1. Water Alert

India is among the countries that will be worst hit by water scarcity in the new millennium and is expected to be severely water stressed by 2005. More than 100 million people in 12 states are in the grip of drought in the worst ever water crisis of the past 50 years, a grim portent of a barren future. Our water related problems arise principally from unplanned use and misuse of natural resources, coupled with their gross neglect and pollution.

The quality of available water is also fast deteriorating. In 1982 it was reported that 70% of all available water in India was polluted. The situation is much worse today. Over-extraction of ground water has led to salt water intrusion into coastal aquifers. It has also resulted in problems of excessive fluoride, iron, arsenic and salinity in water affecting about 44 million people in India. Ground water is facing an equally serious threat from contamination by industrial effluent and faecal matter, as well as pesticides and fertilisers from farm run-offs.

Unless priority is given quickly to creating an infrastructure to assure availability of water, there may be no water to meet the agricultural, domestic and industrial needs of a population that has tripled in 50 years to one billion.

When basic components so interdependent, the water treatment industry can no longer limit itself just to water treatment but must also concern itself with ensuring availability of water. The industry will, in fact, service its own interests best by working to meet the basic needs of people and protecting the environment on which life and business depend. Thus as IEI, our mission has been total water management. This includes development and promotion of water efficient and water saving techniques that also reduce use of resources like energy and thus the load on the environment.

2. Industrial Water Usage and Waste

While water consumption continues to rise as our economy thrives, shortage and increase in the cost of reliable fresh water supplies has become major limiting factor effecting the growth of industries in general. Due to water scarcity problems, nearly 1000 manufacturing companies in several sectors namely textiles, pharmaceuticals, paper, refineries and petrochemicals have declared water as one of the major bottlenecks for the future of industrial growth in the country.

The annual water consumption by industrial sector in India is estimated to be 40,000 million cubic meters. The annual waste water discharge from the industries is 30,000 million cubic meters. Brackish water is abundantly available along northern coast and sea water is virtually unlimited along the west and the eastern coasts of India. Using Membrane process, sea water desalination and water recycle concepts were pioneered and continue to be promoted as effective and economical way of solving water scarcity by IEI.

3. Current and Emerging Trends in SWRO

Multistage Flash (MSF) attained the base load for large scale production in the Middle East, but in India, since the setting up of first sea water desalination plant at GEB Sikka in the year 1996, Birla group company Indian Rayon and Industries Ltd., Veraval in the year 2000, GHCL, Veraval in the year 2000, Ion Exchange India has demonstrated SWRO as a viable alternative to the three major distillation processes; MSF, Multi Evaporator Distillation (MED) and Vapour Compression (VC). Today SWRO process has advanced to such level in our country, that it can be claimed as backbone of desalination industry.

The real challenge for promoting Reverse Osmosis (RO) technology was in getting the over all cost of producing desalination water compared to alternate thermal desalination process. This objective continues, to deliver water through SWRO at further competitive and with higher degree of reliability.

The key parameters that affect desalination plant cost can be broadly classified into the following groups :

- Plant size
- Process type and design
- Finance costs
- Feed water quality
- Intake type
- O&M requirement and
- Environment Discharge

The cost of the units have come down to about Rs. 75000/m^3 of installed capacity, which is about 50% less compared with the 1990s. The cost variation is high in case of brackish water desalination plants, because they are very sensitive to feed water quality. However, brackish water desalination equipment is usually less than 50% of the se water equipment cost.

In general, water production costs for SWRO plants installed by us are distributed as follows :

- 38% Capital investment
- 20.5% Energy
- 21.3% Labour
- 16.2% Maintenance
- 4% Chemicals

The race to reduce further power consumption of SWRO system continues. The major steps towards achieving this objective have been Membrane optimization, introducing UF/MF in the pretreatment and developing efficiency energy recovery systems. The latest development of higher pressure feed pump with better efficiencies have added a new dimension to the race. This paper attempts to cover the following key aspects related to SWRO process.

a) <u>Cost of technology:-</u>

Technology should be able to complete on a scale basis with thermal desalination process. SWRO's assets of lower capital, shorter construction time and smaller plot area when compared with a single-purpose MSF plant are well understood and appreciated.

b) Running costs:-

Inspite of improvements in technology, membrane replacement costs can still be exorbitant. With membrane life varying between 3 to 5 yeas, the annual membrane replacement costs can be as high as 5% of the total RO plant cost.

c) Plant recovery:-

The current industry standard for the recovery rate in a SWRO plant is 35-40%. Toray Industries and Toray Engineering have developed new type RO membranes and it's process for sea water desalination, which brings advantages of high water recovery (60%), low energy cost (3.5 kWh/m^3) and lower plant installation cost.

The new type RO membranes, that is called "Brine Conversion Reverse Osmosis Membrane (SU-820BCM)", shows a superb performance at a high pressure more than 9.0 Mpa and a high salt concentration more than 5.8% concentrated sea water.

d) Energy Recovery:-

Work in this field involves the utilization of various energy recovery devices, the latest of which is reported to reduce unit water energy consumption to 2.5 kWh/m^3. This is a fourfold improvement over the last 10 years.

e) Plant size:-

Today RO train size matches the standard MSF unit size of 12 to 15 MIGD. This higher unit sizes however offer several advantages such as less equipment, fewer spares, less plant area etc.

f) Pretreatment and Membranes:-

Surface sea water intended for desalination by RO needs extensive pretreatment to control membrane fouling. Currently, conventional pretreatment is applied, consisting mainly of in-line flocculation followed by media filtration.

This kind of pretreatment usually yields satisfactory results, provided a well designed sea water intake system usually a submarine type is used. However, considering long-term membrane performance stability, membrane manufacturers usually limit the operating flux in order to avoid frequent chemical membrane cleaning. Due to advancement in MF and UF technologies, their implementation for water filtration was dramatically expanded in the last several years and several hundred systems are in operation for municipal drinking water systems worldwide. These new backwashable MF/UF technologies have been widely considered as pretreatment for RO plants operating with polluted surface water such as river water, agriculture and municipal waste water with superior quality performance.

The main reason for not adopting this technology for pretreatment in SWRO systems until lately, stems mainly from economic reasons and to some extent to lack of operational experience with sea water. Continuous cost reduction in MF/UF membranes cost and especially their reduced cost in large systems, now makes this option attractive also for pretreatment in large SWRO systems operating on surface feed water, originating from an open intake source.

Our experience indicates that the relatively higher investments for this technology in comparison with conventional pretreatment has partially and in most cases fully compensated by cost reduction in downstream SWRO system by enabling higher permeate flux rate, permeate recovery and significant reduction in membrane cleaning cost.

4. Water conservation through recycle

Water recycle, a concept which IEI has been promoting, is an effective and economical way of solving water scarcity. Recycle – of industrial effluent, domestic sullage and urban sewage, not only conserves vast volumes of water, but also protects the environment by reducing pollution.

a) Industry – Experiencing the Gains:-

Industries that have installed our effluent recycle systems have gained a good payback on their investment. Our company has the highest

installations and largest volumes of treated effluent recycled through these membrane processes.

- assured availability of water for process needs as well as low end uses;
- less requirement of fresh water and lower water costs;
- additional savings through recovery of valuable by-products for re-use in process;
- compliance with pollution control regulations and a cleaner environment through reduced effluent discharge.

For new projects, incorporation of recycle considerably reduces capital investment on water treatment.

b) Water Assurance for Homes:-

Applying the concept of recycle to the domestic sector, which consumes 80% of urban water supplies, IEI has launched sullage recycle systems for residential complexes. These are also ideal for hotels, hospitals and large institutions like schools and colleges. Here, sullage (water from the kitchens and bathrooms) is treated and recycled for toilet flushing and gardening, reducing the requirement of fresh water by upto 60%. It costs less than tanker water while providing a better quality and makes more fresh water available for other purposes.

The sullage recycle system is compact, easy to install and simple to operate. The simple construction and affordable capital cost make it easy for new and existing buildings to go in for the system and payback is often within a year. If required, IEI's service company network undertakes annual maintenance contracts for trouble free operation of the system.

c) Membrane Bioreactor (MBR) for waste reuse:-

Subsequently IEI installed a MBR based sullage/recycle system in the premises of a major construction company. This was shown to be feasible for water reuse and offers several benefits over the conventional activated sludge process.

Based on the pilot studies, IEI has commissioned the first membrane bioreactor system to be installed in India for recycling 600 m^3/d of effluent generated in the industry shortly.

5. Water Reuse v/s Desalination:-

In this section, we will compare the cost of water reuse in comparison to the cost of sea water desalination plant. The capital costs for a plant producing water from sea water are about 50% higher than the costs of a plant reusing secondary sewage. Both the pretreatment costs and RO cost are higher. In the case of pretreatment, this is due to the difference in recovery (75% for secondary effluent, 50% for se water), which results in a large sea water system. The capital cost for the sea water RO process is higher than for the secondary effluent RO as it is operating at a much higher pressure, lower permeate flux, lower recovery and must be made of material that resist corrosion in sea water.

Similarly, the O&M costs for producing RO water from se water are about 3 times higher than the cost of resulting secondary sewage. The higher pretreatment costs are due to chemicals, continuous dosage of a coagulant and higher dosage of antiscalant. The higher RO costs are due to primarily energy (the operating pressure is 5 times higher and the feed flow is 1.5 times higher, but also to membrane replacement.

The total life cycle costs for producing RO water from secondary effluent and sea water are Rs. 15/m^3 and Rs. 37.5/m^3.

6. Sustainable Solutions:-

Good water management is crucial to overcome the water crisis that threatens the country. IEI is proud to be in a business that is of such beneficial service to society and the environment and privileged to lead the water treatment industry in India in total water management.

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