DSS for SWRO Plant O&M
Technical experience and lessons learned from O&M of a membrane based water plant

Dr. Senthilmurugan, Technology Manager – ABB Water Industry Segment Initiative, 17 – April - 2012
O&M of SWRO plant

Content of talk

- ABB profile in water Market
- Challenges in O&M of SWRO plant
- Importance of DSS for O&M of SWRO plant
- Asset management of SWRO plant
  - Membranes, Pumps, ERD’s, Pretreatment filters etc.
- Advance operation of SWRO plant
  - Energy optimization (operation of RO / NF/UF/MF membranes, Pumps, ERD’s, filters etc.)
  - Maintenance schedule optimization (membranes, pumps)
- ABB’s solution for O&M of SWRO plant
  - Optimax® Membrane Performance
  - DSS for O&M of SWRO plant
ABB in Water cycle
Where do we operate in Water market and applications?

- ABB profile in water Market
- Challenges
- Importance of DSS
- Asset Management
- Advance operation
- ABB’ solution
- Summary

**Trends:**
- Water Conservation
- Energy Efficiency
- Reuse
- Total water mgmt.
- Zero liquid discharge

**INDUSTRY WATER**
- Industrial Pumping stations
- Industrial Water Treatment
- Industrial Wastewater Treatment

**IRRIGATION WATER**
- Pumping stations
- Irrigation Network

**Desalination plants**

**Waste Water Treatment Plants**

**Water Network**

**Raw water Pumping station**

**Water Discharge & Monitoring**

**Water Abstraction & Monitoring**
A proper selection and operation of pretreatment process … will prevent or minimize bio fouling, scaling and membrane plugging in reverse osmosis units.

Optimal operation and accurate control of flow and pressure to pretreatment system … leads to energy minimization in pretreatment and RO section.

… leads to life extension for RO and pretreatment filters.

… also leads to minimal performance degradation of membrane due to fouling.

Typical maintenance activities of pretreatment units to sustain plant production level such as:

… Flushing of membrane (order of days)

… Chemical cleaning of membrane (order of months)

… Partial replacement / full replacement of membrane elements (order of years)
High pressure is applied at membrane feed side…
  …to overcome the osmotic pressure of the solute
  …to cause transport of the solvent from feed side to permeate side (product water)

Particles accumulate near the membrane surface (concentration polarization) → concentration increases over time → membrane performance decreases

Membrane fouling rate due to concentration polarization is influenced by multiple factors, e.g. changes in process conditions (temperature, feed flow concentration,…)

Root cause analysis for changing fouling rate is difficult

Actions to overcome fouling include cleaning (backwashing, chemical cleaning), membrane exchange, change of pump setpoints to keep productivity level
SWRO desalination plant O&M activities

Challenges in Maintenance of SWRO plant

- Major process units of SWRO plant
  - RO, UF / MF membranes of pretreatment units, Pumps, ERD
- Due to fouling the membrane under goes for regular maintenances actives such as
  - Flushing of membrane (order of days)
  - Cleaning of membrane (order of months)
  - Partial replacement / full replacement of membrane elements (order of years)
- Due to regular wear and tear of pumps, ERD, the efficiency of pumps varies ~ ± 5%, the maintenance activities are
  - Maintenance for mechanical components
- Challenge: how to schedule of maintenance activates of membrane systems
  - To optimize water production cost
  - To minimize carbon footprint per m³ of water production
Decision support system (DSS) for SWRO plant

Importance of scheduling membrane maintenance activities

- Membrane fouling monitoring and its impact on membrane chemical cleaning schedules, and optimization of RO process (Gauder et al., 2010) is important

- Lu et al., (2006) determined optimal membrane maintenance schedules without considering the membrane life cycle into optimization problem formulation

- ABB’s DSS for SWRO calculates the optimal membrane maintenance schedules
  - By minimizing water production cost over membrane life time
  - Also helps in minimizing the specific energy consumption (SEC) of the plant by optimally distributing the production load among RO trains.

- The proposed DSS consists of several functionalities, namely, scheduler, load distributor, membrane management system and simulator.
Decision support system (DSS) for SWRO Scheduler

- Estimation of optimal membrane maintenance schedules
- Reduces unplanned plant outages due to non-optimal schedules.
- Minimizes the overall water production cost during membrane life cycle and considers constraints on product quality - in order to maintain acceptable salt level in the product water, product water demand - in order to achieve the plant production target, and also concentration polarization factor - to improve membrane life time, during optimization.
- The trend of water permeability parameter with respect to membrane chemical cleaning and replacement schedules (refer Fig)
- The water permeability increases as and when the membrane gets cleaned or replaced.
- The optimal schedule is always better than fixed schedule in terms of production cost

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Decision support system (DSS) for SWRO Membrane Management System (MMS)

- Provides the membrane operational and maintenance history for analysis like
  - Any violations (process or maintenance) happened in past operation
  - Provides proof for membrane warranty from operation perspectives
- It can extracts events like cleaning and chemical and water usage back flushing and chemical cleaning
- It also facilitates operator to represent process violations by means of rules.
- It will provide % hrs of plant is operated above threshold value recommended by supplier and OEM
- Compares the OEM and optimal schedules

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<th>Operation</th>
<th>OEM Schedules</th>
<th>Optimal Schedules</th>
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In RO plant, several RO trains will be running in parallel.

Each train will have different membrane fouling status.

Trains that are more fouled require more energy to produce the same quantity of product water.

Optimal production load distribution among RO trains is required to minimize overall SEC of a RO section.

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**SEC vs Product flow rate**

- **Old membrane**
- **New membrane**

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**SEC vs Product flow**

- **Optimal**
- **Scenario 2**
- **Scenario 3**
- **Scenario 1**

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The simulator helps the operator to validate different scenarios which otherwise cannot be tested in the real plant.

It helps the operator in analyzing the effect of operational and maintenance parameters (such as feed flow, feed pressure and number of membrane cleanings) on the production cost.

Simulator allows to compare different membrane maintenance schedules in terms of cost ($/m3 of product water produced).
ABB’s solution for SWRO plant
Advance Operation and Maintenance

- Optimax® Membrane Performance
  - Monitor membrane fouling and optimize membrane operation including pumps and Membranes
  - Overcomes known drawbacks of other approaches (ASTM and thumb rule)
  - Provides advanced operation of membrane systems
  - Consists of two modules:
    - Module 1: Online Membrane Performance Monitoring
    - Module 2: Online Membrane Process Optimization
  - Applicable for membrane systems based on Reverse Osmosis (RO) and Nano-Filtration (NF) treatment technology
  - Model-based membrane monitoring solution for individual membrane trains
  - For more details: http://www.abb.com/water
Scheduler
- Provides optimal schedule for membrane maintenance activities
  - When the membrane are to be cleaned and replaced
  - How much % of membranes are to be replaced

Membrane Management System
- Provides operational and maintenance history
- Displays process violations via alarms
  - Conditions for process violations can be provided by means of rules

Load distributor
- Provides optimal production load distribution between RO trains
  - Optimal production load distribution minimizes overall specific energy consumption

Simulator
- Facilitates to validate what-if scenarios
  - How energy consumption changes with process variables
  - How production cost changes with membrane maintenance activities
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