“Pulse Flow RO” for Extremely High Recovery

Without Scaling
Without Fouling

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Pulse Flow RO Works

› Operation
  › Production: Dead End, 100% recovery, about 200 seconds, followed by
  › Flushing: High shearing velocity reject flow discharge, about 4 seconds
Pulse Flow Operation

› Three successful pilots
HP Pump Operation Regime

- Dead-end 100% recovery
- Reject flow

Reject discharge and Permeate production.
Pulse Flush Pilot in Hadera RO Plant
Short Stay in an Extremely High Concentration allows reaching Extremely High Recovery

› The pulse flow RO process
  › Fast increase of brine flow concentration during Production (Dead-End 100% recovery)
  › Fast decrease of brine flow concentration during short time reject flush
Slow Dynamics of the Nucleation Process

Relatively Slow Dynamics of the Nucleation Process, compare to short time stay of PFRO brine in membranes, allows reach extremely high recovery.

The mathematical model represents the actual time required for formation of a CaCO$_3$ layer on the existing proto-crystals.
Expert Design Model

› Pulse flow RO

› Results of low conductivity test

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<thead>
<tr>
<th>Std</th>
<th>Run</th>
<th>Factor 1 A: Production</th>
<th>Factor 2 B: Flushing</th>
<th>Factor 3 C: Cond feed</th>
<th>Response 1 Product flow</th>
<th>Response 2 Product conductivity</th>
<th>Response 3 Recovery</th>
<th>Response 4 Rejection</th>
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<td>TF</td>
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</table>
1-stage PFRO versus 4-stage BWRO

BWRO boron removal 4 stages

R98.4%

PFRO 1 stage

Membrane: Hydranautics ESPA-2-LD 8040
Not pumping brine flow continuously results in ~20% Power Saving

PFRO production requires a smaller feed pump
- 95% of the time only permeate is pumped
- 5% of the time reject flow is pumped
Practical Implementation of Pulse Flow RO

› Retrofit existing RO train or an additional Pulse-Flow RO stand can be installed
Brine Squeezer Micro Pilot

Equipment List
- Pressure vessel 4” 1 element
- RO membrane 4” x 1
- Pump Danfoss APP-0.6
- Motor 2.5kW
- VSD
- Coax Solenoid valve x 3
- Tanks 100L x 2

Instrument List
- Pressure Transmitters 01; 02; 03; 0-100 bar
- Level switch on/off 01; 02; 03; 04; 05.
- Conductivity on line 01; 02.

I/O List
- Motor 2.5kW
- VSD
- Coax Solenoid valve 01; 02; 03; 24VDC
ON/OFF PVC Solenoid valves: 04; 05; 24VDC
- Pressure Transmitters x 3
- Level switches x 5
- Conductivity on line 01; 02.
Micro Pilot - RO Reject Brine Squeezer

Capacity 2000 GPD, Recovery 50%-90%
2.5 kw motor