CE 530
Reverse osmosis

The illustration shows: supply unit (left) and trainer (right), screen mirroring is possible on different end devices

Description

- **membrane separation process for obtaining solvent from a salt solution**
- **spiral wound membrane module for separation**
- **plant control using an integrated PLC**
- **integrated router for operation and control via an end device and for screen mirroring on additional end devices: PC, tablet, smartphone**

This trainer has been developed in cooperation with the **Institute for Thermal Process Engineering at the TU Hamburg-Harburg**. A solution of NaCl in a defined concentration (up to 3,2% max.) is mixed in a tank complete with a stirring machine. A pump delivers the solution to the spiral wound membrane module. The pump generates the necessary pressure for separation.

The spiral wound membrane module consists of multiple membrane envelopes. A membrane envelope is made up of two membranes with a porous spacer between them. The membrane envelope is sealed on three sides and on its fourth, open, side is connected to the perforated permeate collecting tube. There are other spacers between the envelopes to ensure axial flow of the salt solution. The spacers together with the membrane envelopes are wound spirally around the permeate collecting tube.

The salt solution arrives at the front face of the module and flows axially between the envelopes. The semi-permeable membrane is permeable to water (permeate) but not to dissolved NaCl. The applied pressure forces the water through the membrane into the envelopes. In the envelopes the water flows spirally towards the permeate collecting tube and exits the module in an axial direction. As a result of the water being removed, the solution is concentrated as it travels through the module. It exits the module as retentate and is returned to the raw water tank. The permeate is collected in a separate tank. In order to check the success of the separation, salt concentrations in the raw water, retentate and permeate are recorded by measuring the respective conductivity values.

The trainer is controlled by the PLC via touch screen. The pressure and flow rate can be adjusted by valves. By means of an integrated router, the trainer can alternatively be operated and controlled via an end device. The user interface can also be displayed on additional end devices (screen mirroring). Via the PLC, the measured values can be stored internally. Access to stored measured values is possible from end devices via WLAN with integrated router/LAN connection to the customer's own network.

Learning objectives/experiments

- assembly, cleaning and conservation of membrane modules
- fundamental principle of reverse osmosis
  - Van't Hoff's law
- permeate flow rate and retention dependent on
  - pressure
  - salt concentration in raw water
  - yield
- determination of diffusion coefficients
- screen mirroring: mirroring of the user interface on end devices
  - menu navigation independent of the user interface shown on the touch screen
  - different user levels available on the end device: for observing the experiments or for operation and control

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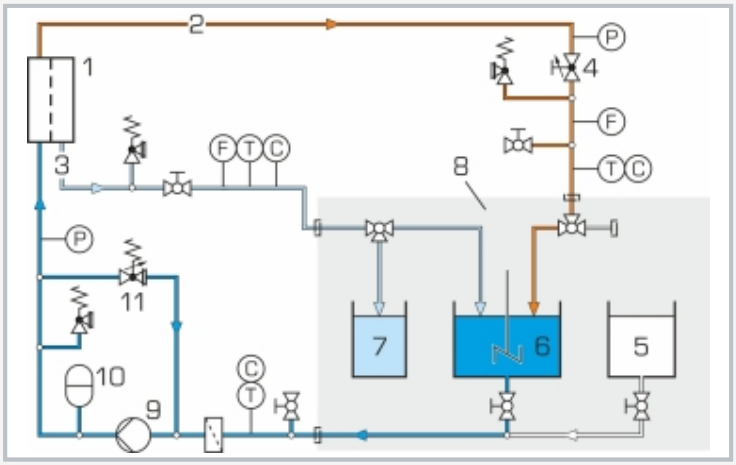
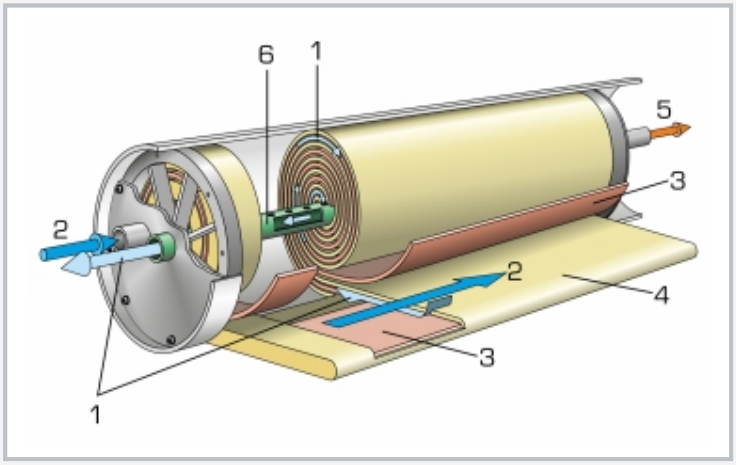
1 rinsing water tank (distilled water), 2 raw water tank (salt solution), 3 stirring machine, 4 manometer, 5 spiral wound membrane module, 6 pump with motor, 7 valves, 8 PLC with touch screen



1 spiral wound membrane module, 2 retentate, 3 permeate, 4 retentate valve, 5 rinsing water (distilled water), 6 raw water (salt solution), 7 permeate, 8 supply unit, 9 pump, 10 pulsation damper, 11 overflow valve; P pressure, F flow rate, T temperature, C conductivity



Spiral wound membrane module: 1 permeate, 2 raw water, 3 spacer, 4 membrane envelope, 5 retentate, 6 permeate collecting tube

Specification

[1] removal of solvent from a salt solution using reverse osmosis
[2] polyamide spiral wound membrane module
[3] piston pump with pulsation damper for pressure generation
[4] overflow valve to adjust the pressure upstream of the membrane module
[5] valve to adjust the retentate flow rate
[6] safety cutout to protect the pump against dry running
[7] plant control with PLC via touch screen
[8] integrated router for operation and control via an end device and for screen mirroring: mirroring of the user interface on up to 5 end devices
[9] data acquisition via PLC on internal memory, access to stored measured values via WLAN/LAN with integrated router/LAN connection to customer's own network or direct LAN connection without customer network

Technical data

PLC: Eaton XV-303

Spiral wound membrane module, active area: 1,2m^2
- raw water flow rate: max. 1,4m^3/h
- length: approx. 533mm, Ø approx. 61mm

Piston pump: max. flow rate: approx. 585L/h, max. pressure: approx. 140bar

Operating pressure: max. 58bar

Stirring machine
- power consumption: 130W
- speed: 50...1000min^{-1}

Tanks
- raw water (salt solution, 3,2% max.): approx. 110L
- rinsing water (distilled water): approx. 110L
- permeate: approx. 5L

Measuring ranges
- flow rate: 0,5...7,5L/min (retentate), 0,05...1,8L/min (permeate)
- temperature: 3x 0...60°C
- pressure: 4x 0...100bar (2x manometer, 2x sensor)
- conductivity: 3x 0...200mS/cm

230V, 50Hz, 1 phase; 230V, 60Hz, 1 phase
120V, 60Hz, 1 phase; UL/CSA optional
LxWxH: 1250x1050x2100mm (trainer)
LxWxH: 1500x1050x1400mm (supply unit)
Total weight: approx. 290kg

Required for operation

water connection, drain, sodium chloride (NaCl), distilled water, sodium disulfite (conservation of the membrane module), caustic soda, hydrochloric acid

Scope of delivery

trainer, supply unit, membrane, conservation tank, 1 set of accessories, 3x conductivity meter, 1 set of instructional material