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High pressure reverse osmosis for wastewater minimization and zero liquid discharge applications

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1. Introduction

As a result of the significant impact of industrial waste on nature, the requirements for waste water treatment tight up: wastewater minimization and zero liquid discharge (ZLD) are the demanding targets for several applications. Both are normally reached with the combination of several treatment and concentrating steps, finished by a thermal process. Reverse osmosis (RO), as a common step in such systems, is normally limited to around 75% recovery due to scaling or osmotic pressure. The concentration factor of the RO determines concentrate volume, thus size and cost of the final thermal stage. Therefore every percent of recovery increase is an improvement. With high pressure reverse osmosis (HPRO) the cost efficiency of those systems can be increased significantly. HPRO systems work at pressures of 140 bar and above, which requires special module constructions and membranes. This paper covers PALL Disc Tube HPRO technology, used to achieve higher recovery at much higher pressures than currently experienced and thereby reducing or eliminating thermal based technologies.

2. Theory and experimental

Industrial applications have special system and module requirements regarding corrosion and temperature stability in addition to the necessary high pressure stability. Different HPRO module constructions will be introduced.

As common RO-membranes tend to show severe compaction at high pressures, several trials were made to find a suitable membrane for the ZLD applications. The tests were done with two special systems: a high pressure test cell for flat sheet membranes and short term trials and an automated test system for full-size modules with 7.5 m^2 membrane area for long-term tests. The results of these tests were compared to find similarities and upscale rules.

3. Results and discussion

The trials show a significant time dependency of permeate flux in the first days of operation. For a comparison of the two test series

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this time impact needs to be considered. An upscale from the test cell values to a full-size module furthermore has to take into account that the recovery in both tests is differing significantly and therefore such upscale can only give rough estimations.

4. Conclusions

High Pressure Reverse Osmosis for Waste Minimization and Zero Liquid Discharge applications are a demanding task. Special membranes, modules and systems are required to serve this market. Although the permeability at 140 bar or higher is below common values for standard applications like sea water, the cost efficiency is usually given. PALL found suitable modules and membranes to provide HPRO-systems which reduce size and investment costs for the final thermal stage. Testing of several membranes has shown that test cell trials are good to compare different membranes. For the system design full-size long term trials are indispensable.