Water separation from potash mining dump leachate by membrane distillation

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Abstract

In Germany, several million cubic meters of high-salinity leachate are produced every year from tailings dumps of potash salt mining. This leachate is predominantly discharged into nearby surface waters. This must be reduced drastically to protect the rivers. Established processing methods such as reverse osmosis or evaporation are ruled out for technical or economic reasons. Membrane distillation (MD) is a relatively new technology for concentrating saline solutions, which is also suitable for high salt concentrations. Advantages are expected from the use of low-calorie heat sources and low investment costs.

The solubility of sodium chloride in water is 320 g/l and is almost independent of temperature. The addition of magnesium chloride reduces the solubility of sodium chloride with a simultaneous increase in temperature dependence. This behavior is used to further dewater NaCl-saturated leachate through a combination of membrane distillation and cooling crystallization. This produces pure water, solid salt and an aqueous salt solution, fulfilling the specifications to be implemented into a backfilling concept of a saline mine (Fig. 1).

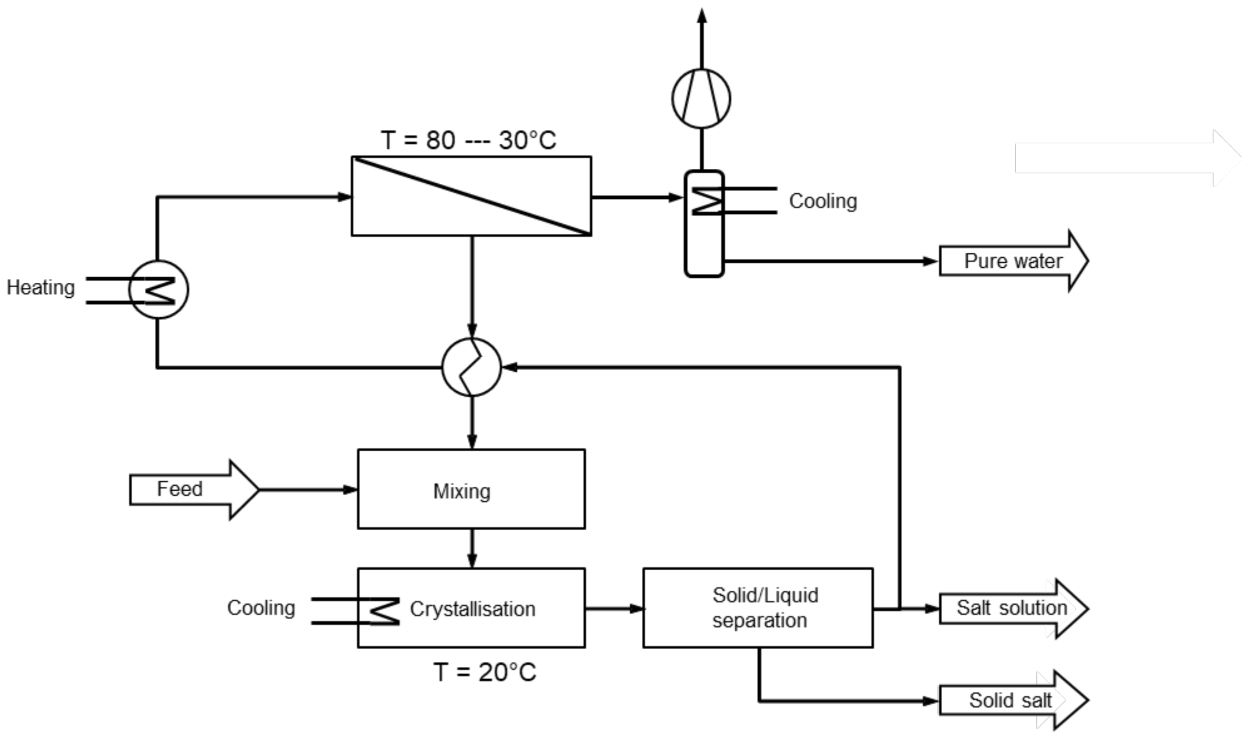

Fig.1: Process scheme to use membrane distillation for water separation from leachate of potash mining dumps.

Membrane distillation in this application operates close to solubility. There is also a high risk of surface crystallization and membrane blocking due to concentration polarization. For these reasons, ceramic membranes are preferably tested for this application.

Ceramic membranes are hydrophilic and must be made hydrophobic for use in membrane distillation. This is achieved through surface modification using silanes [1]. Laboratory tests on membrane distillation with these membranes showed no wetting over a trial interval of 77 hours (Fig. 2). During the first two days water was extracted by the membrane and salt concentration was increased to the point of saturation, where crystals were consistently optically detectable in the feed during the experiment. After this point was reached the concentration was kept constant by returning permeate water into feed mixture. In this part of the experiment, the feed mixture was certainly at the saturation limit for over 28 hours. At the saturation limit, a stable flow of about 5.2 kg/(m^{2}h) was observed.

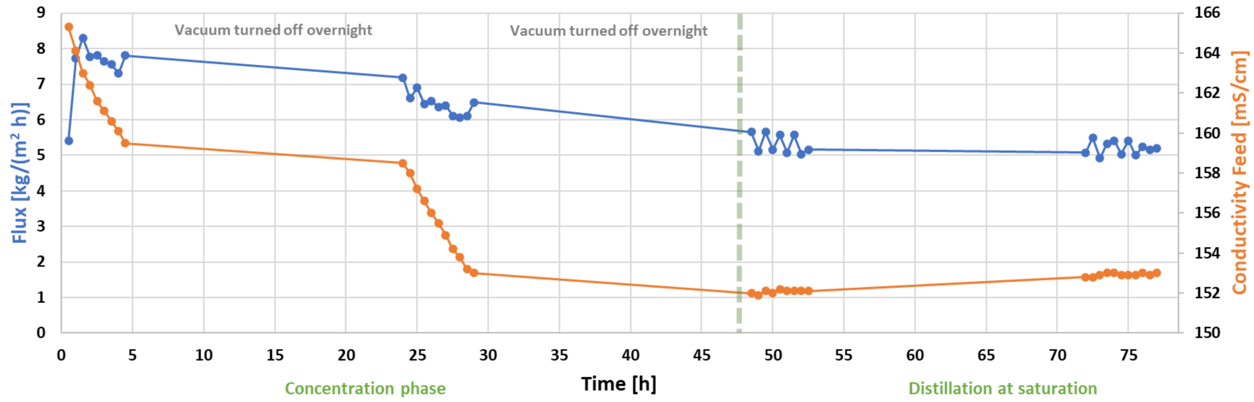

Fig. 2: Flux behavior of a ceramic MD-membrane during dewatering of a solution consisting initially of 240 g magnesium chloride, 79 g sodium chloride, 68 g potassium chloride and 57 g sodium sulfate each 1000 ml of water. The feed temperature was 70 °C with a feed cross flow velocity of 0.7 m/s and a permeate pressure of 100 mbar.

Based on these promising laboratory tests, a membrane system with integrated cooling crystallization and a GOR (gain output ratio) greater than 2 will be developed and tested with real dump leachate.

Acknowledgement

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References

[1] Schnittger, J., McCutcheon, J.R., Hoyer, T., Weyd, M., Voigt, I., Lerch, A., “Modified ceramic membranes for the treatment of highly saline mixtures utilized in vacuum membrane distillation”, Desalination 567 (2023) 116943