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Performance of a RED system with ammonium hydrogen carbonate solutions

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The continuous increase of global energy requirements has raised the interest towards the development of new technologies to recover waste heat. Thermodynamic cycles are traditionally employed to convert heat into power but they can work normally with heat sources at medium-high temperatures. The use of closed-loop salinity gradient power (SGP) technologies has been recently presented as a viable option to generate power using low grade heat, by coupling a SGP unit with a thermally-driven regeneration process in a closed loop where artificial solutions using different salts and solvents can be adopted for the conversion of heat-into-power. Among these, the closed-loop reverse electrodialysis (RED) process presents a number of advantages such as the direct production of electricity, the extreme flexibility in operating conditions and the recently-demonstrated large potentials for industrial scale-up.

Ammonium hydrogen carbonate is a salt suitable for such closed-loop reverse electrodialysis process thanks to its particular properties. At temperatures above 40-45°C, it decomposes into a gaseous phase containing NH_3 and CO_2. Thus, the use of NH_4-HCO_3 solutions for feeding a RED unit would allow their easy regeneration (after the power generation step) just using waste heat in a purposely designed regeneration unit. Up to now, three different applications have been proposed in the literature for the exploitation of NH_4-HCO_3 in "SGP-engines": ammonia-carbon dioxide osmotic heat engine, thermal-driven electrochemical generator (TDEG) and microbial reverse electrodialysis cell (MRC). This work aims at presenting a preliminary experimental investigation for the case of NH_4-HCO_3 in a RED-closed-loop system. Laboratory tests have been carried out to find the best condition maximizing the power density and process performances of a RED unit by investigating a number of operating parameters such as fluid velocity, feed solutions concentration and temperature, flow rates ratios, etc.

Keywords: Reverse electrodialysis, Salinity gradient power, SGP heat engine, Waste heat, Ammonium hydrogen carbonate

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Lab-scale investigation of a pressure retarded osmosis module fed by "non-conventional" salinity gradients

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Power generation from salinity gradient is a viable alternative to produce energy from renewable sources. Pressure retarded osmosis (PRO) has been proposed so far for the exploitation of

such energy source. In PRO water from a low salinity feed solution permeates through an osmotic membrane into a pressurized high salinity draw solution, thus naturally increasing the pressure energy of the pressurized stream. Power is eventually obtained from the pressurized stream adopting water turbines or using it in pressure exchanger/turbo-chargers for pressurizing a different stream, thus saving electrical/mechanical energy.A part from the typical source of salinity gradients, namely river water and sea water, more and more interest has been raised recently towards the use of non conventional saline solutions, such as waters from a waste-water treatment plant or desalination brines. However, the main limitation in the process still remains the performances of osmotic membranes in terms of water fluxes, mechanical robustness and resistance against fouling phenomena.

Aim of this work has been to investigate the feasibility of PRO technology for power generation from saline streams originated by different water treatments plants, namely brine from a thermal desalination plant and fresh water from a sewage treatment plant.Two lab-scale test-rigs were designed and built in order to assess the performances of several osmotic membranes, under various operating conditions.The first one exhibits a conventional planar geometry cell, operated under atmospheric pressure (forward osmosis or depressurized-PRO operations).The second test-rig is comprised of a customized cylindrical membrane module, able to mechanically support the osmotic membrane.The newly developed module allows for controlled contact between the two solutions under pressurized operating conditions.Artificial solutions at different salt concentration and two real saline solutions were adopted for the experimental campaign. Results have highlighted the differences between membranes and module configurations. Long-run tests have also indicated a different decline in performance when adopting real solutions rather than artificial ones, providing useful indications on how fouling phenomena can affect the membrane behavior and highlighting the importance of counteracting them by different operating strategies.

Keywords: Salinity gradient power, PRO, Forward osmosis, Brine, Wastewater, Energy recovery

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Modelling the transient behaviour of a MED-TVC plant for coupling with CSP

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Thermal vapour compression multi-effect distillation (MED-TVC) is among the most popular desalination processes for the coupling with solar energy application, especially when solar thermal energy is concerned. Several models have been developed so far and presented in the open literature, though most of them can not simulate a number of secondary phenomena, which can have significant importance in the simulation of transient behaviour of the MED unit. In this paper a dynamic model for the MED-TVC process has been developed, and validated by a comparison with data from a real plant situated in Trapani, Italy, composed by 12 effects with parallel-feed configuration and equipped with a medium-pressure steam vapour ejector. The model was implemented using gPROMS®, a powerful dynamic modelling platform for process simulation. The transient comportment