

Reverse Electrodialysis Process with Seawater and Concentrated Brines: A COMSOL Multiphysics® Model for Equipment Design

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Abstract

Salinity Gradient Power (SGP) is a promising renewable energy source associated to the controlled mixing of two aqueous solutions of different salinities. Recently, Reverse Electrodialysis process (SGP-RE, or RED) has been identified as a successful way for the exploitation of such energy source, allowing the conversion of SGP directly into electric energy. This technology is based on the use of suitable ion-exchange membranes (IEMs) within a device formally similar to commercial electrodialysis units (Figure 1). A comprehensive mathematical model is clearly helpful in order to simulate the system behavior and optimize the process performance. On the other hand, the SGP-RE process presents several crucial aspects to be modeled, such as transport phenomena through ion-exchange membranes, characterization of fluid flow behaviour inside spacer-filled channels, description of electrochemical reactions at the electrode-solution interface.

In this paper a novel FEM model using COMSOL Multiphysics® is proposed for the SGP-RE process using seawater and concentrated brine as feed solutions. The aim of such modelling approach has been to achieve the description, within a single modelling environment, of both fluid flow behaviour along channels and electrochemical phenomena inside the system. COMSOL Multiphysics® modelling activities have started focusing on the transport phenomena through membranes, assuming a laminar flow regime inside empty channels and describing the salt flux as transport of diluted electrolyte solutions. Moreover, a simplified model has been adopted to describe the electrode kinetics within the external compartments, so as to investigate the effect of the redox couple concentration on process performance. Afterwards, a preliminary calibration/validation of the proposed model has been carried out using experimental data collected within the EU-FP7 REAPower project activities.

In spite of its simplifying approach, the developed COMSOL Multiphysics® model can simulate correctly all the main phenomena involved in the process, e.g. giving the trend of both concentration and voltage profiles inside the system. As a results, the model address several aspects of the process at the same time, providing useful indications for further development of the SGP-RE process.

Figures used in the abstract

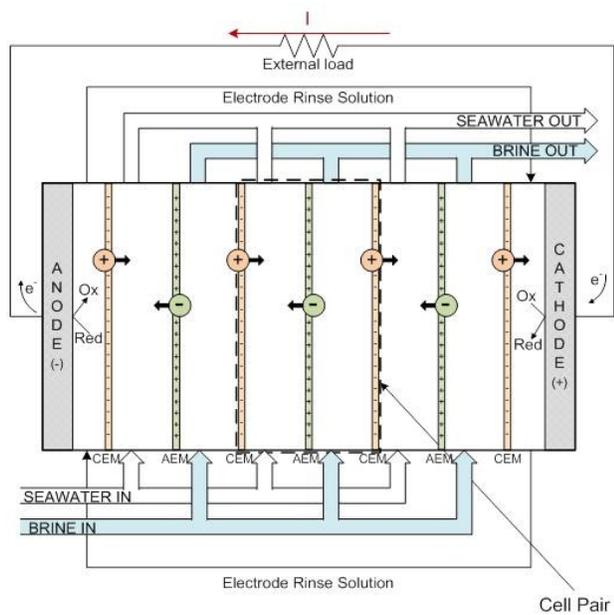


Figure 1: Principle of SGP-RE process