APPLICATION OF ADVANCED MEMBRANE SYSTEMS IN NUCLEAR DESALINATION OF WATER

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ABSTRACT

Desalination is high-energy consuming process, which uses much of electricity, usually drawn from conventional fossil-fuelled plants, but it can also use low-temperature heat sources like solar energy or waste heat from power plants or industrial processes. The twin production system combining generation of energy by nuclear reactors and turning the seawater into potable water known as “nuclear desalination” seems economically viable in many water shortage regions.

Application of membrane processes like membrane distillation (MD) and reverse osmosis (RO), separately or in combined systems, is proposed for water desalination. The driving force of MD is temperature gradient across the membrane that generates vapour pressure difference. The temperature of the feed solution is below its boiling point. Because of that MD can use low-enthalpy sources of heat, e.g. waste heat or solar energy. It seems to be a cost effective method anywhere, where sources of waste heat are available, e.g. in convential or nuclear power plants. The pressure-driven process of RO, can be intensified by applying elevated temperatures.

Keywords: nuclear desalination, reverse osmosis, membrane distillation

1. Introduction

Although water is the most widely occurring substance on the earth, only 2.53 % is freshwater in rivers, lakes and aquifers, while the rest is salt water. As at the beginning of 21st century the Earth is facing a serious water crisis, there is a need to look for new methods of production of potable water from seawater, which resources are inexhaustible. Desalination is high-energy consuming process, which uses much of electricity, usually drawn from conventional fossil-fuelled plants, but it can also use low-temperature heat sources like solar energy or waste heat. In the past decades there is an interest in using nuclear energy for production of fresh water. The twin production system combining generation of energy by nuclear reactors and turning the seawater into potable water known as “nuclear desalination” seems economically viable in many water shortage regions. It was shown that small and medium-sized nuclear reactors are convenient for that purpose; they can be used for desalination, often with co-generation of electricity using low-pressure steam for the turbine and hot seawater feed from the final cooling system.

The common technologies used for desalination are the multi-stage flash (MSF) evaporation process using steam, and reverse osmosis (RO) which is driven by high-pressure electric pumps. Less often desalination plants use multi-effect distillation (MED) or vapour compression (VC). The hybrid plants coupling two different processes, acting synergistically were also considered, like MSF-RO, which allows obtaining products of different quality, depending on specific needs [1-3].

Application of membrane processes like membrane distillation (MD) and reverse osmosis, separately or in combined systems, is proposed for water desalination.

2. Reverse Osmosis vs. Membrane Desalination

Reverse osmosis (RO) became a common method for water desalination [4-6]. The process uses semipermeable membrane which is capable to remove various types of molecules and ions from solutions. In RO, applied pressure overcomes osmotic pressure which depends on concentration of the solute. As a result the solute remains on the pressurized side of the membrane, while pure solvent (water) passes to the other side (Figure 1).

Membrane distillation (MD) is a separation process which involves evaporation of an aqueous solution being in contact with one side of a porous hydrophobic membrane, followed by transport of the water vapour through the pores of the hydrophobic membrane, and condensation of the vapour transported on the other side of the membrane (Figure 2) [7-8]. The driving force of MD is temperature gradient across the membrane that generates vapour pressure difference. The temperature of the feed solution is below its boiling point. Because of that MD can use low-enthalpy sources of heat, e.g. waste heat or solar energy. Moreover it does not involve high pressures at all. It seems to be a cost effective method anywhere, where sources of waste heat are available, e.g. in convential or nuclear power plants. RO is pressure-driven process, however it is intensified when works at elevated temperatures. Both processes can be considered as components of low-temperature desalination systems employed in nuclear desalination.

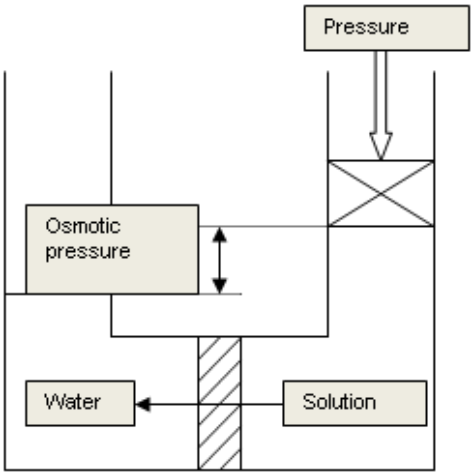

Figure 1. Reverse Osmosis

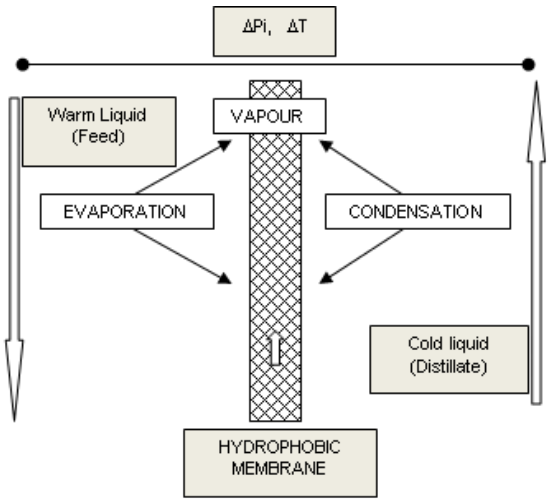

Figure 2. Membrane distillation

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