Osmotic Pressure Generation Model for a Pressure Retarded Osmosis System

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Oil and gas production is the largest energy production field in the world. When these products are extracted a large volume of fresh water is utilized to drill wells, lubricate drilling equipment, and extract fossil fuels. What is left over after these processes is called produced water, which is the largest waste stream generated by oil and gas industries [1]. This produced water can have extremely high levels of dissolved salts (TDS). In New Mexico, over 20 billion gallons of produced water are generated annually, most of it coming from the Permian Basin [2]. The produced water varies from 1% to 40% TDS, compared with seawater at 3.5% [2]. This water is composed of various salts at varying concentrations as well as biological impurities. Instead of storing this waste water in salt water disposal wells, it has been proposed to use pressure retarded osmosis (PRO) to generate power. PRO is a form of osmosis where a high salinity and a low salinity water source are separated by a semi-permeable membrane. Water naturally passes through the membrane from low salinity to high salinity via forward osmosis. In a PRO process, a pressure is also applied to the high salinity side retarding the flow across the membrane. This results in a pressurized exit stream from the high salinity side which will be used to generate power. This applied pressure also alters the system so it cannot reach equilibrium and runs continuously. In order to create a PRO system a theoretical thermodynamic model of expected osmotic pressures was developed. These osmotic pressures were dependent on the water activity and chemical potential difference between the various salts in the two water sources. To produce this model, the program ChemCAD was used to find the vapor pressure and saturation points of various salts, which was then incorporated into Van't Hoff's equation. The

model displayed the maximum osmotic pressure to be approximately 46,000 psi for magnesium chloride, and the minimum osmotic pressure to be approximately 450 psi for potassium sulfate. The major salt components for a sample of produced water are sodium chloride with an expected osmotic pressure of approximately 5,400 psi and sodium sulfate with an expected osmotic pressure of approximately 2,300 psi. This theoretical model will be utilized by comparison to results acquired from a bench scale PRO system.

References

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