AN ANALYTICAL MODEL AND OPTIMIZATION OF DISTILLATION POWERED BY A VAPOR PRESSURE DIFFERENCE DUE TO A SALINITY DIFFERENCE

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ABSTRACT

Strategies for harnessing energy from salinity difference have been studied for many years. The earliest strategies were impractical and expensive; these involved the use of ion selective or semipermeable osmotic membranes. A different approach which eliminates the need for membranes was introduced in the late seventies. This method exploits the vapor pressure difference between two waters of different salinity. This method has limitations in that a large vapor transfer and a large amount of heat transfer are required in order to produce a small amount of power. The present study also uses vapor transfer. Instead of directly harnessing the vapor pressure difference to produce power, however, it would exploit the elevated temperatures produced during the non-isothermal absorption of vapor on the surface of concentrated brine. In the new device, this elevated temperature would be used to drive a single stage of fresh water distillation.

In this study a detailed computer model of the device has been developed. The model considers the simultaneous heat and mass transfer in the films of seawater and hygroscopic brine flowing down the surfaces of vertical heat exchanger plates. Non-condensable gases are not

considered in the analysis. The analysis also considers the minimum wetting rate of the falling films. This is the minimum film flowrate required so that falling films do not break up into dry patches. The device will be optimized based on water inlet flowrates, heat exchanger material, and type of concentrated brine solution used. This study concludes that the fresh water production is mainly controlled by inlet flows of seawater and concentrated brine. Minimum flows of seawater minimize the internal pumping power requirement and maximize the fresh water production. The thermal resistance across the falling films dominates the resistance across the heat exchanger plates. Therefore, plastic HDPE could be used as the heat exchanger material without greatly reducing the device's performance. When the gap between films of seawater and concentrated brine is too small, heat will be conducted back to the seawater through the vapor phase from the warmer brine. As a result, more seawater will evaporate and dilute the brine further. Therefore, too small a gap thickness between these films reduces performance.