TITLE: Innovative Fresh Water Production Process for Fossil Fuel Plants

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GRANT NO: DE-FG26-02NT41537

PERIOD OF PERFORMANCE: April 2004 – April 2005

DATE: April 5, 2005

1. Abstract

Project Rationale and Objective

Between 1900 and 1995, drinking water demand has grown twice as fast as the world population. By 2025, this demand should grow another 40% (World Resources 2000 - 2001). In fifty years, about forty countries will lack adequate drinking water without further technological developments. An obvious solution to the fresh water shortage problem is seawater desalination. Desalination technologies are currently used throughout the world and have been under development for the past century. In the United States there exists significant interest in developing clean-coal technologies for electricity generation to meet the growing electricity demand. Approximately 30 gallons of fresh water are required for every kWh of power produced from coal. This places fossil fired power plants in direct competition with processing industries and municipalities for fresh water resources that are on the decline. Recently Klausner et al. (2004) described an innovative Diffusion Driven Desalination (DDD) process for the distillation of mineralized water. The energy source to drive the process is derived from low pressure condensing steam within the main condenser of a steam power generating plant. Since waste heat is used to drive the process, the main cost of fresh water production is attributed to the energy cost of pumping air and water through the packed bed. A detailed thermal transport analysis demonstrates that the DDD process can yield a fresh water production of 1.03 million gallon/day by utilizing waste heat from a 100 MW steam power plant based on a condensing steam pressure of only 3" Hg. The objective of this research project is to study the performance of the DDD process over a wide range of possible operating conditions and develop the necessary engineering models to scale it up from a laboratory facility to a full-scale desalination plant producing millions of gallons of fresh water per day.

Accomplishments Achieved During the Current Period of Performance

The main focus for this performance period has been on the diffusion tower and direct contact condenser. Water evaporation for the DDD process occurs within the diffusion tower, and vapor condensation occurs in the direct contact condenser. An experimental facility has been fabricated that includes a diffusion tower and direct contact condenser. Extensive heat and mass transfer measurements have been compiled. Modifications to the condenser and parallel experiments have been made to improve the effectiveness of the condenser. Figure 1 shows a pictorial view of the lab scale DDD experiment.

Figure 1 Pictorial view of the lab scale DDD experiment

Extensive measurements of pressure drop through the diffusion tower have been made, and a correlation has been developed for predicting the pressure drop. Using the thermal model and pressure drop correlation, the required energy to produce a unit of fresh water has been thoroughly analyzed. As an example, consider a 100 MW power plant where the thermal efficiency is 40%. There is a potential to produce as much as 1.03 million gallons/day of fresh water assuming the feed water temperature enters the diffusion tower at 46° C. The energy consumption from the seawater, air, and cold fresh water pumps in the DDD process is about 0.0053 kW-hr per kilogram of fresh water. Thus the electrical power requirement is 0.87 MW in total, and the required land footprint is about 1211 m^2.

Plans for the Remaining Performance Period

- Develop analytical models for predicting the heat and mass transfer performance within the direct contact condenser
- Evaluate the fresh water production rate using the laboratory scale DDD facility over a wide range of operating conditions
- Utilize the analytical models to project the performance of the DDD process for a full scale desalination plant integrated with a typical coal-fired power plant

Publication

[1] Klausner, J.F., Li,Y., Mei, R., 2004, *Heat and Mass Transfer for the Diffusion Driven Desalination Process*, ASME-ZSIS International Thermal Science Seminar ITSS II.

[2] Klausner, J.F., Mei, R., and Li,Y. et al., 2004, *Innovative Fresh Water Production Process for Fossil Fuel Plants*, U.S. DOE - Energy Information Administration annual report.

[3] Klausner, J.F., Li,Y., Mei, R., 2004, *Innovative diffusion driven desalination process*, Journal of Energy Resources Technology.

[4] Green Alex E.S., Klausner J. F., Li Y., 2004, *A Green Alliance of Natural Gas, Biomass and Utility Desalination (GANGBUD)*, Tampa Clear Water Conference, Tampa, Florida.

[5] Klausner, J.F., Mei, R., and Li,Y. et al., 2003, *Innovative Fresh Water Production Process for Fossil Fuel Plants*, U.S. DOE - Energy Information Administration annual report.

[6] Klausner, J.F., Darwish, M.Y., and Mei, R., 2003, *Computational Method and Design of a Packed Bed Diffusion Tower for the Desalination of Seawater*, Proceedings of the 2003 ASME Summer Heat Transfer Conference, paper HT2003-40438, Las Vegas, July 21-23

Proposed Publication

[1] Klausner J.F., Li Y., Mei R., 2005, *Evaporative Heat and Mass Transfer for the Diffusion Driven Desalination Process*, in press Journal of Heat and Mass Transfer, Springer Verlag.

[2] Li Y., Klausner J.F., Mei R., 2005, *Performance Characteristics of the Diffusion Driven Desalination Process*, in press International Water Conference, Orlando, Florida.

Patent
Diffusion Driven Desalination Apparatus and Process, patent pending

Award
DOE Award Number DE-FG26-O2NT41537

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