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Solar Driven Desalination

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Description: With the advancement of renewable energy utilization for seawater desalination, solar energy is projected to be a promising energy source for seawater distillation. The current approach is to develop a low temperature solar energy driven distillation process that is based on direct evaporation and condensation of water vapor through a packed bed using an air stream. Transient one-dimensional conservation equations have been developed to analyze the heat and mass transfer within direct-contact evaporators and condensers. Closure models have been specified. The conservation equations are solved numerically using a finite difference scheme to predict water, air/vapor mixture and packed bed temperatures in the evaporator and the condenser. The heat and mass transport model accounts for the transient variations within the packed-bed due to changes in the inlet air and water temperature over the course of the experiment. Set of experiments are conducted and used to validate the transient models. The developed model will be used to predict fresh water production at various operating conditions. The transient computer model will be used to design solar driven desalination plants and analyze the economics of construction and operation.

Budget: $252,000

Universities: UF

Progress Summary

Research Objectives: The research objective for the current reporting period is to set up an experimental diffusion driven desalination facility and experimentally validate a computer models developed for the transient evaporation and condensation processes based on solar heating.

Progress Made Toward Objectives During Reporting Period: An experimental diffusion driven desalination facility that operates in a transient mode has been fabricated. The facility operates in a recirculation mode, and the discharge brine from the diffusion tower circulates through a simulated solar water heater. The 15 kW simulated solar water heated is computer controlled so that the transient heating of the water matches that of a solar water heater for various sky conditions over an eight hour period. The main body of the evaporator and condenser is a transparent column constructed with 24.1 cm ID acrylic tubing with wall thickness of 0.64 cm and 1 m height. Experimental desalination experiments are done for the evaporator operating at water inlet mass fluxes of 1.0, and 2.15 kg/m^2-s and air mass fluxes of 0.5, and 1.0 kg/m^2-s. The experimental condenser facility operates with water mass fluxes of 1.0, and 2.0 kg/m^2-s and air mass fluxes of 0.5, and 1.0 kg/m^2-s. The heights of the packed bed within the evaporator and condenser are 0.91 m, and 0.7 m, respectively.

Figure 1(a) shows a comparison of the measured and computed exit air and water temperatures discharging the diffusion tower for different air mass fluxes. Figure 1(b) shows the comparison for the condenser. The computed exit water and air temperatures are in good agreement with those measured. For a 2.0 m^2 solar collector area, the predicted fresh water production per number of collectors per day is 14 L/collector-day. It is believed that the water production can be improved further by optimizing the system operating conditions.

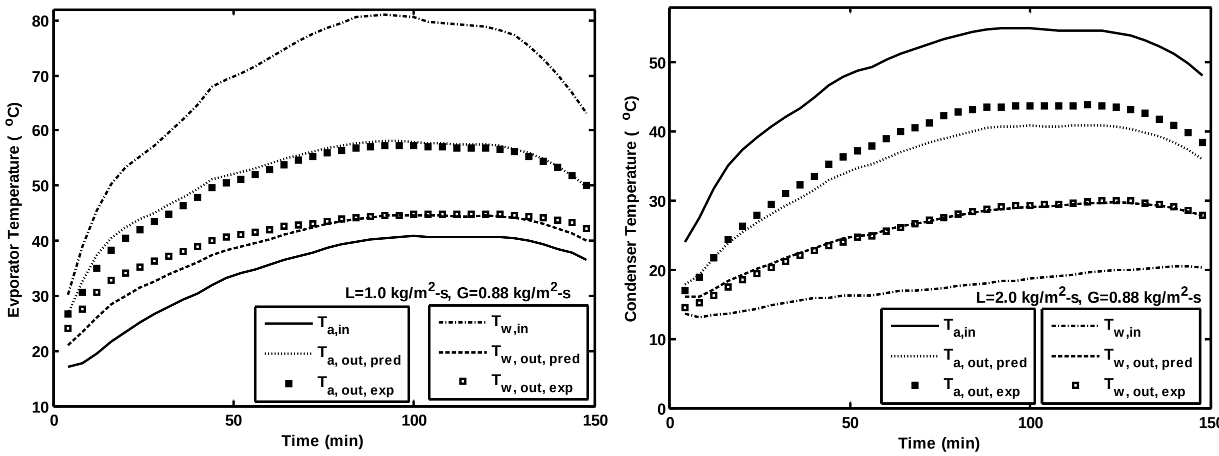

Figure 1 Exit air and water temperature variation from the a) diffusion tower and b) condenser.

The computer model appears to provide a very good predictive capability for the thermal and mass transport within the diffusion tower and condenser. The computer model will be utilized as a design tool to identify the optimal operating conditions and analyze the performance of the desalination processes for various size solar collector facilities. In addition, a comprehensive economic analysis of the solar driven desalination process will be undertaken. Particular attention will be paid to the cost of construction, and the break even point for an initial investment. The computer model will also be used to guide the scale-up of the facility for both large and small scale applications.