Faculty of Engineering- Fayoum University

Mechanical Engineering Department

كلية الهندسة- جامعة الفيوم

قسم الهندسة الميكانيكية

Summary of the Ph.D. Thesis

"Study of Hybrid Solar Desalination System depends on Air humidification and Dehumidification with Water Flashing Evaporation "

This thesis presents experimental and theoretical simulation of a novel hybrid sustainable solar desalination process consisting of a humidification–dehumidification unit and single stage flashing evaporation unit (HDH-SSF) configured by a nano-fluid solar water heater. The study includes the following main stages: analysis, design, manufacturing and outdoor testing of the experimental unit in the laboratory of faculty of engineering at Tanta University, Tanta city. The hybrid solar desalination system is studied theoretically. The heat and mass transfer and flow field are modeled theoretically in two dimensions using the finite difference scheme. Theoretical simulations were performed using a detailed computer code employing fundamental physical and thermodynamic laws. The heat transfer and flow field of nano-fluid solar collector loop is modeled numerically by a three- dimensional CFD code. For different operating and weather conditions, the fresh water productivity and salinity are computed. The model is developed to investigate the steady-state behavior of each component of the system. Seven main parameters that have an influence on the system productivity are studied: feed water mass flow rate of SSF unit, feed water mass flow rate of HDH unit, cooling water mass flow rate of SSF unit, cooling water mass flow rate of HDH unit, air mass flow rate, inlet cooling water temperature and nano-particle volume fraction. An experimental validation is carried out and its results are compared with the theoretical ones at different conditions and time sequence. This comparison displays a good agreement between the experimental and theoretical simulation. An economic analysis was performed to show the economic benefits and the feasibility measurement for the system. The TCO (total cost of ownership) concept was adopted in this analysis. A hybrid desalination system (HDH-SSF) has been investigated for four different configurations include the conventional system, which is formed of HDH and SSF unit in standalone layout in addition to three different configurations of hybrid and standalone layouts. The characteristics of these configurations in different layouts and working conditions are studied in order to evaluate four main parameters; water cost, productivity, thermal performance and environmental impacts. The results show that, the studied hybrid desalination system gives a significant operational compatibility between the air humidification–dehumidification method and

flash evaporation desalination with expected daily water production up to 94.21 liter/day or 11.14 liter/m^2/day. The efficiency of the system is measured by the gained output ratio (GOR). The gained output ratio (GOR) of the system reaches 6. Based on the cost of energy in Egypt, the estimated cost of the generated potable water of the hybrid system was 7.79 US$/$m^3$. The current study showed that, the solar water heater collecting area and the plant lifetime are considered significant factors for reducing the water production cost. Also; the produced water costs decrease with increasing both the collecting area of the solar water heater and the plant lifetime. The volume fractions of nano-particle in solar collector working fluid have a significant impact on increasing the fresh water production and decreasing cost. The hybrid HDH-SSF with solar air heater represents the best economical configuration.