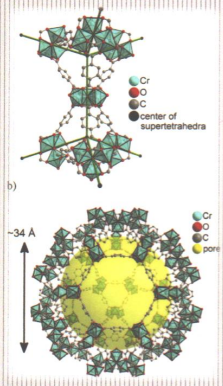
IMPRES

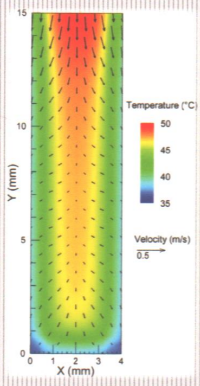
Chemical Science and Engineering Series 4

Innovative Materials for Processes in Energy Systems

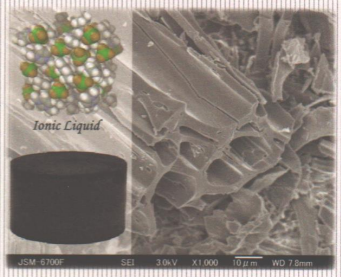
Carbon dioxide



MOF



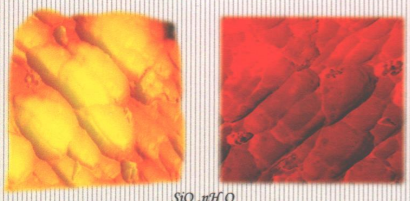
CFD analysis



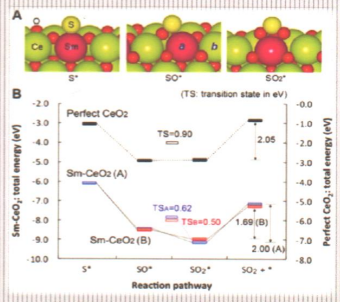
Composite adsorbent

Water

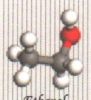
Methane



$SiO_2.nH_2O$



SO_2 formation on CeO_2 and Sm-doped CeO_2



Ethanol

Editors:
Bidyut Baran Saha and Angelo Freni

I²CNER

About the Editors

Bidyut Baran Saha obtained his B.Sc. (Hons.) and M.Sc. degrees from Dhaka University of Bangladesh in 1987 and 1990, respectively. He received his Ph.D. in 1997 from the Tokyo University of Agriculture and Technology, Japan. He worked as an Associate Professor at the Interdisciplinary Graduate School of Engineering Sciences of Kyushu University until 2008. He worked as a Senior Research Fellow at the Mechanical Engineering Department of National University of Singapore prior to joining the Mechanical Engineering Department of Kyushu University in 2010 as a Professor. He joined the Kyushu University Program for Leading Graduate School, Green Asia Education Center in March 2013 as a professor. Currently, he has been working as a professor and principal investigator at the International Institute for Carbon-Neutral Energy Research (WPI-I2CNER) in the Division of Thermal Science and Engineering. His main research interests are thermally powered sorption systems, heat and mass transfer analysis, and energy efficiency assessment. He has published more than 300 articles in peer-reviewed journals and international conference proceedings. He has edited four books and holds 14 patents. Recently, he served as Managing Guest Editor for Applied Thermal Engineering and Heat Transfer Engineering journals, and Editor-in-Chief of Evergreen. He has organized and chairman of the International Conference on Innovative Materials for Processes in Energy Systems (IMPRES) conferences.

Angelo Freni graduated in Materials Engineering in 1998. He holds a Ph.D. in Materials and Chemical Engineering from the University of Messina. He joined as fellow researcher the Italian National Council of Research- Institute for Advanced Energy Technologies (CNR-ITAE) - Messina in 1999. Since 2001 he is Full Researcher at CNR ITAE, carrying out research and project development and management in the field of energy technologies with special regard to thermally-driven heat pumps, heat storage and hydrogen storage systems. He has published more than 150 papers in peer-reviewed journals and international conference proceedings, plus 3 patents. He has been carrying out and leading scientific activities in the framework of National and International programs, in co-operation with industries and research groups. He regularly serves on the Scientific Committee of international Conferences as well as session chairman. He was also involved in the organizing committee of national and international workshops and conferences. As part of his activity, he is also involved in the supervision of students at different levels (PhD, MSc, BSc, and lectures at CNR ITAE and University of Messina, where he has hold the course of Fluid Machinery from 2005 to 2008. He is the Italian alternate delegate in the Executive Committee of the IEA - Heat Pump Program organization. He is member of the commission "E2 - Heat pumps, energy recovery" of the IIR – International Institute of Refrigeration.

ISBN978-4-944005-21-5

9784944005215

Chemical heat pumps

Desalination

Desiccant systems

Thermal performance simulation of a heat pump assisted solar desalination system for Kazakhstan climate conditions

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1. Introduction

Lack of fresh water is one of the key problems of Kazakhstan. According to UN estimates, over the past 50 years, providing the population with water resources in Central Asia declined by almost 3.5 times and, according to estimates, by the year 2025 may reach the critical exponent - 1.7 cubic meters per person per year. At the same time, Kazakhstan is one of the leading countries in the Central Asian region with the average annual solar radiation potential. Annual duration of sunshine is 2200-3000 hours, and the estimated capacity of 1300-1700 kW per 1 m^2 per year, which exceeds that of Europe. In this context, the use of solar desalination, combined with a heat pump system will provide fresh water to residents of remote areas with access to salt or polluted water.

2. System description

The schematic diagram of the heat pump assisted solar desalination system is depicted in Figure 1.

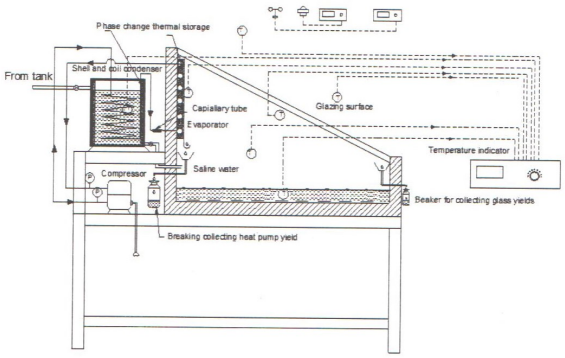

Fig.1: Schematic view of the heat pump assisted regenerative solar still.

Innovative Materials for Processes in Energy Systems 2016
Editors: Bidyut Baran Saha, Angelo Freni
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ISBN: 978-4-944005-21-5, IMPRES2016-012

The heat pump assisted regenerative solar still consists of a hermetically sealed reciprocating compressor, a shell and coil type condenser with thermal storage, a liquid receiver, a sealed-type refrigerant drier, a thermostatic expansion device, plate type evaporator with heat storage provision, basin area 2 m^2 that accommodates brackish water. The condenser will contribute to heat basin water (evaporation), especially during low solar radiation using heat pump refrigerant (R134a). The water in the basin is heated by the incident solar radiation transmitted through the glazing surface. The water will condense under this glass cover and the evaporator. The condensate will be collected by two beakers.

3. Mathematical model and method of solution

Mathematical model based on mass and energy balance equations for different part of heat pump assisted solar desalination system according to [1]. Numerical algorithm for differential equations solution based on the fourth order Runge-Kutta method [1]. Computer program for implementation of numerical algorithm developed by means of C++ programming software. As the initial conditions for temperature at the different part of the heat pump assisted solar still ambient temperature were assumed. At the first time step this temperature value was used to calculate convective and radiative heat transfer coefficients. Based on this values and physical properties temperatures at the different positions of the system were calculated.

4. Results and discussion

Temperature variation of different parts of the distiller was numerically estimated for climate conditions of Fort-Shevchenko town in Kazakhstan. Fort-Shevchenko is located on the eastern shore of Caspian Sea. Figure 1 shows the temperature variation and productivity of solar still.

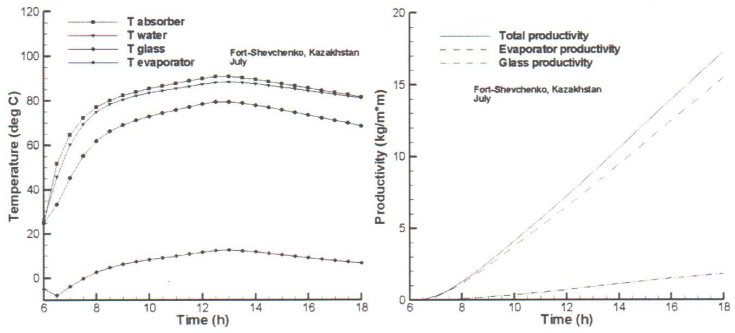

Fig.2: Temperature variation of the different parts of solar still and productivity estimation.

According to the Figure 2 maximum absorber temperature reaches a value 91 °C for July. More than 75% of condensed water is produced by evaporator comparing to glass cover. A large amount of water vapor is condensate very quickly due to the low temperature of the refrigerant [2].

References

[1] Hanen Ben Halima, Nader Frikha, Romdhane Ben Slama, Numerical investigation of a simple solar still coupled to a compression heat pump, Desalination, 337 (2014) 60-66.

[2] M. Mohanraj, S. Jayaraj, S. Muraleedharan, Performance prediction of a direct expansion solar assisted heat pump using artificial neural networks, Applied Energy, 86 (2009) 1442-1449.