Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 90 (2016) 283 – 291

Energy Procedia

5th International Conference on Advances in Energy Research, ICAER 2015, 15-17 December 2015, Mumbai, India

Experimental analysis of augmented desalination by cooling integration

[a,*]C. Chiranjeevi, [b]T. Srinivas

[a, b] *CO2Research and Green Technologies Centre, Department of Thermal and Energy Engineering, School of Mechanical Engineering, VIT University, Vellore 632014, India*

Abstract

This work evaluates a two-stage humidification-dehumidification (HDH) process for combined air cooling and desalination for fresh water production from salt water experimentally. A pilot scale plant is designed and constructed with 16 m^2 solar collector area for salt water heating. The operational parameters identified are hot saline water supply to humidifiers and it's temperature. The saline water is heated in a solar water heater (SWH) and supplied to the two humidifiers and air preheaters. Main performance parameters i.e. desalinated water generation, cooling effect and energy utilization factor (EUF) of the plant is studied in the light of hot water inlet temperature and its flow rate. It is observed that a maximum of 2.5 LPH of fresh water is produced at a water and air flow rates of 300 LPH and 10 m^3/hr respectively. At low inlet water temperatures the resulted cooling effect is more compared with high temperatures and an average of 120 W of cooling effect is produced. The energy utilization factor (EUF) of combined two stage desalination and cooling plant is more compared with individual single stage plants and an average value of 0.4 is attained for combined plant. On overall basis, maximum possible water flow rate in humidifier and also high temperatures are recommended to yield more desalination output.

Peer-review under responsibility of the organizing committee of ICAER 2015

Keywords: desalination; humidification; dehumification; cooling effect.

* Corresponding author. Tel.: +91-7845190906; fax: +91-416-2243092.
E-mail address: chiranjeevi_c@yahoo.com

Peer-review under responsibility of the organizing committee of ICAER 2015
doi:10.1016/j.egypro.2016.11.196

1. Introduction

In past recent years energy conservation and management became a major research area. A lot of research has been done on using renewable energy sources as energy source. Solar energy is major renewable energy source which falls on earth and return back unused is used to get hot water for humidification. Many researchers are looking for systems which can utilize low temperature sources with renewable energy. The proposed plant produces distilled water and cooled air for room cooling with a nominal electric power input for running auxiliary units. Humidification can be done by hot water spray and dehumidification by circulating water, atmospheric air and chilled water. This makes the plant less dependent on electricity, which is ideal for hot places where sun radiation is high and having water scarcity.

Nomenclature

EUF	energy utilization factor
h	specific enthalpy, kJ/kg of dry air
m	mass flow rate, kg/s
Q	heat, kW
W	work, kW

Suffix

APH	air preheater
chw	chilled water
da	dry air
ds	double stage
dw	desalinated water
fg	latent heat
fs	first stage
ss	second stage
hw	hot water

The process of air humidification-dehumidification (HDH) is based on the natural water cycle. This technique is studied and applied by many researchers due to low temperature energy (solar, geothermal, waste heat) use, simplicity, low cost and less payback period. HDH is a best suitable choice for producing fresh water when the demand is decentralized. Orfi et al.[1] did theoretical study on solar desalination system using HDH technique and showed an optimum water to air mass ratio ranges from 1.6 to 2.2 for a maximum yield of 0.05 grams of fresh water per unit kg of dry air. Chiranjeevi and Srinivas [2] developed a model for parametric study of a combined two stage HDH desalination plant integrated with cooling system. Yamli and Solmus [3] did experiment on humidification and dehumidification (HDH) process and concluded that with increase in mass flow rate of the air fresh water productivity remains same. Prakash Narayan et al. [4] constructed and carried out on a pilot scale HDH unit and validated the design models developed. Further the optimization of heat and mass exchange devises have been studied with the experimental data. Dai and Zhang [5] have investigated the performance of a solar desalination system experimentally. It is found that the performance of the system is strongly depends on the salt water temperature of inlet to the humidifier, the mass flow rate and the mass flow rate of air. Farhad et.al. [6] conducted an experimental and theoretical energy and exergy analysis of a solar desalination system consisting of a solar collector and a humidification tower. The developed model is validated against the experimental data, an effective design of a humidification tower can be designed from the results. Orfi et al. [7] conducted an experiment on a water desalination system using solar energy and compared the results with the mathematical model. The results show that there exists an optimum mass flow rate ratio corresponding to a maximum fresh water production. Zamen et al. [8] designed, constructed and conducted experiments on a two-stage pilot plant. Experimental results show that the productivity can be increased by 20% compared with single stage unit. Mehrgoo and Amidpour [9] used the Lagrangian multipliers and genetic algorithm (GA) methods to optimize the production rate in HDH system subject