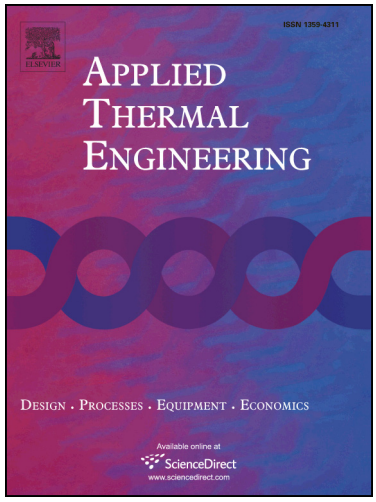

Research Paper

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Aicha Chorak, Patricia Palenzuela, Diego-César Alarcón-Padilla, Abdellatif Ben Abdellah

PII: S1359-4311(16)32321-3
DOI: http://dx.doi.org/10.1016/j.applthermaleng.2017.03.115
Reference: ATE 10119

To appear in: *Applied Thermal Engineering*

Received Date: 10 October 2016
Revised Date: 21 March 2017
Accepted Date: 25 March 2017

Please cite this article as: A. Chorak, P. Palenzuela, D-C. Alarcón-Padilla, A.B. Abdellah, Experimental characterization of a multi-effect distillation system coupled to a flat plate solar collector field: empirical correlations, *Applied Thermal Engineering* (2017), doi: http://dx.doi.org/10.1016/j.applthermaleng.2017.03.115

Experimental characterization of a multi-effect distillation system coupled to a flat plate solar collector field: empirical correlations

Aicha Chorak[1, 2], Patricia Palenzuela[3*], Diego-César Alarcón-Padilla[3], Abdellatif Ben Abdellah [1,2]

[1]Abdelmalek Essaâdi University, Faculty of Science and Technology of Tangier, Ziaten. BP: 416, Tangier, Morocco;
[2]International University of Rabat, Technopolis Rabat-Shore Rocade, Sale, Morocco;
[3]CIEMAT-Plataforma Solar de Almería, Ctra. de Senés s/n, 04200 Tabernas, Almería, Spain
*Corresponding author. E-mail address: patricia.palenzuela@psa.es

Abstract

In the last three decades, developments in desalination plants have been focused on the minimization of its energetic consumption and cost. Advancements include emerging technologies that make use of low grade thermal energy, like Multi-Effect Distillation (MED). The energy optimization of MED systems and their coupling with solar thermal technologies have been deeply investigated by the Solar Desalination Unit of the Plataforma Solar de Almería (PSA) through a solar desalination test facility consisting of a MED plant coupled to a static solar field. Recently, the previous solar field composed of compound parabolic concentrators (CPC) has been replaced by a new one with large-aperture flat plate collectors (FPC). In this work, an experimental characterization of the solar MED system under off-design conditions is presented and discussed. The efficiency of the FPCs' solar field at several temperature levels for different climate conditions has been determined. Also, the influence of the variation of key parameters by which the MED plant is controlled (the inlet hot water flow rate (m_{hot}) and temperature (T_{hot}), the feed water flow rate (m_f) and the condenser vapour temperature (T_c)) on the freshwater production and performance ratio (PR), were analysed with an experimental campaign of 82 experiments. The results obtained were used to fit polynomial expressions, validated statistically, that predict the distillate yield and the PR for different operation strategies. The experimental characterization of the desalination plant revealed that the rise in the T_c has the highest impact in the thermal efficiency of the MED unit, and the rise in the m_f has the greatest influence on the distillation production. Moreover, from the analysis of the coupling of the MED plant with the solar field it was found that the thermal storage has an autonomy of up to 6 hours when the MED works with hot water at 65 ºC, which allows the plant to continue the operation even in transient periods (presence of clouds). Also, from a theoretical annual study for the solar MED system, it was found that the annual solar fraction ranges from 30.7% to 42.4%, which leads to an annual distillate production between 6701 m^3 and 11314 m^3, respectively.

Keywords: Large-aperture flat plate collectors; Multi-effect distillation; Off-design experimental analysis; Solar desalination; Empirical correlations

1. Introduction

Due to the geographic coincidence of regions that present water stress and usually have high levels of solar irradiation, seawater desalination processes driven by solar energy seem to be the most promising option to solve the fresh water problems in these zones. For large-scale desalination systems, the best option is indirect desalination systems, which consist on the coupling of a conventional desalination system with the most suitable solar conversion system according to the energy required by the desalination process. Among the distillation methods more frequently used in indirect solar desalination plants, MED is being preferred due to its