Desalination 348 (2014) 39–48

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Simulation and optimization of novel configurations of triple absorption heat transformers integrated to a water desalination system

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HIGHLIGHTS

- Six different configurations of triple absorption heat transformers which are integrated into desalination system are analyzed.
- Crystallization risk is decreased in triple absorption heat transformers.
- Best proposed configuration is capable of producing fresh water for 1131 residual units.
- Economizers play an important role on distilled water productivity

ARTICLE INFO

Article history:
Received 25 November 2013
Received in revised form 2 June 2014
Accepted 4 June 2014
Available online 29 June 2014

Keywords:
Triple absorption heat transformer
LiBr/H_2O
Desalination
Configuration
Economizer effectiveness

ABSTRACT

A thermodynamic analysis of six different configurations of triple absorption heat transformer systems (TAHTs) utilizing H_2O/LiBr as the working pair which is integrated into water desalination systems is conducted in this study. The energy source of the desalination system is provided by the high temperature heat of the absorbers of TAHTs by utilizing the waste heat from a textile factory. A computer program is developed in the EES (Engineering Equation Solver) to study the performance of the system such as; COP, ECOP, distilled water, and absorber utilized heat, and also to optimize them in six different configurations. It is shown that modified configurations of TAHTs can increase the COP and fresh water productivity rather than that of conventional systems. The results indicated that the optimized amount of distilled water produced by the last configuration which is 0.1307 kg/s can supply 1131 residential units.

1. Introduction

By increasing the world's population and growing energy demands, the concern about providing people's essential needs such as fresh water has become one of the most important worries for governments and scientists. Although about 75% of the earth is covered by water, only 2.5% of this huge amount is potable and the other remaining parts are briny water in the oceans [1,2]. Based on salinity and sources of the water, the saline water is categorized as either brackish water or seawater [3]. Providing reliable fresh water from both brackish and sea water is possible by applying desalination system technologies [4]. The most popular and practical desalination method is the distillation process which can be reached by employing a thermal energy source [5].

Finding an approach to reuse the low or mid-level waste heat (60 °C < T < 100 °C) [6] arisen noticeably and commonly from industrial processes, is a tremendous challenge.

Absorption heat transformers (AHTs) seem to be a motivating choice for the aim of energy effectiveness increment in industrial process plants. They possess additional advantages such as CO_2 discharge reduction and the possibility of running with waste heat sources, as well as solar energy[3,7–10], geothermal [11–14] and other sources [15–19].

AHTs are systems which can convey heat at higher temperatures than that of the original sources. The gross temperature lift (GTL) of 50 °C and coefficient of performance (COP) close to 0.5 are accessible by applying single absorption heat transformers [20]. The amount of GTL fundamentally depends on each additional stage added to single absorption heat transformers (SAHT). A double absorption heat transformer (DAHT) can increase the GTL to 80 °C but the COP decreases to 0.36 [21]. Triple absorption heat transformers (TAHT) are capable of enhancing the temperature even to 140 °C higher than that of the source temperature [22]. These GTLs can satisfy the need of thermal energy sources for the distillation processes. Numerous researchers have investigated different configurations of absorption heat transformers integrated to water purification processes throughout recent decades. Parham et al. [23] conducted a study about analyzing and optimizing

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http://dx.doi.org/10.1016/j.desal.2014.06.006
0011-9164/

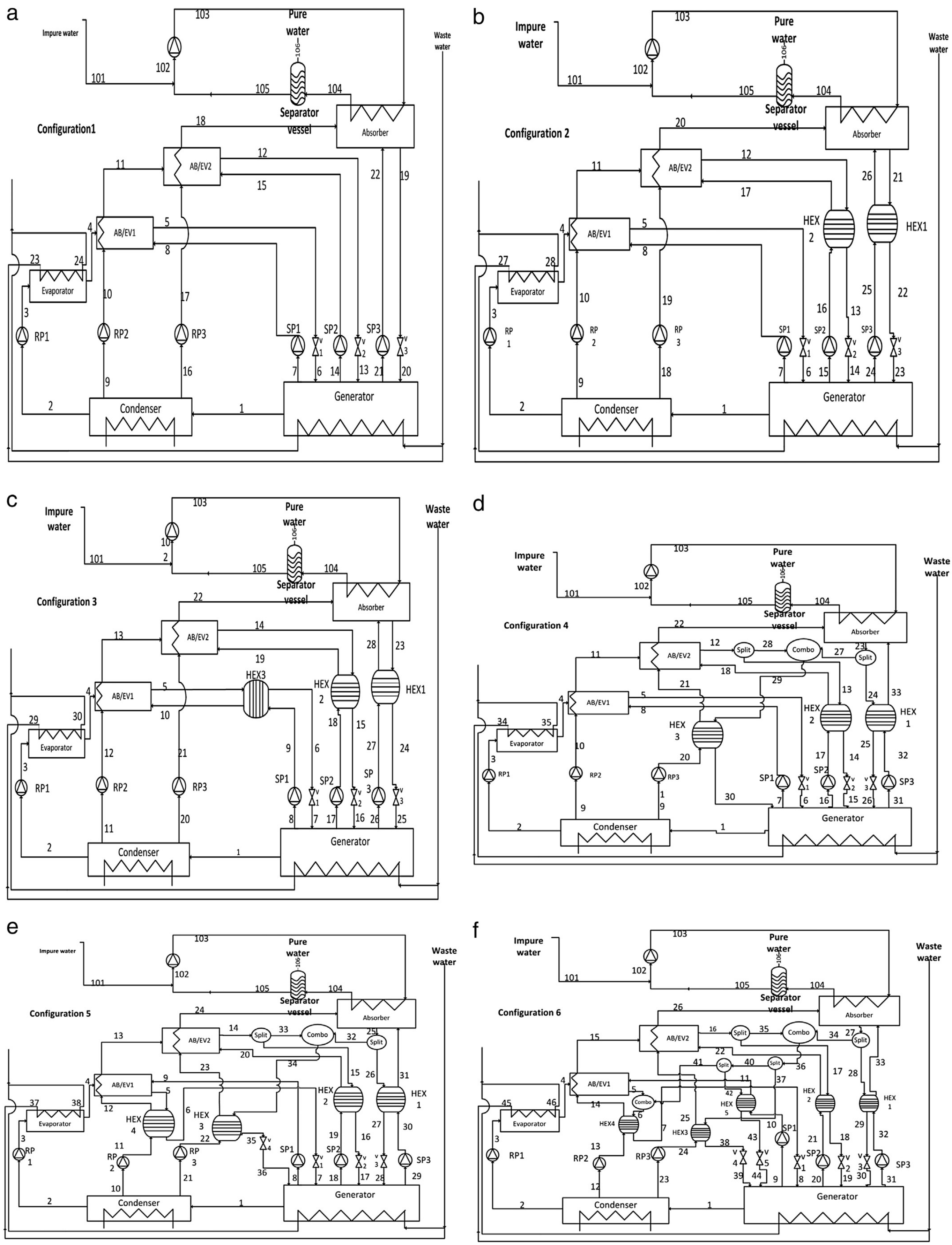

Fig 1. Schematic diagrams of seawater desalination system integrated to alternative triple effect absorption heat transformers.