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A simulation model and parametric study of MED–TVC process

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Abstract

The present work summarizes the MED–TVC (multi effect desalination with thermal vapor compression) technique associated with the state of the art of modern desalination. In addition, a computer simulation model for all types of evaporation processes is presented. This program provides engineers with cost-effective tools for designing, developing and optimizing thermal desalination plants. It is the objective of this article to develop a mathematical model which would predict the influence of all factors on heat transfer coefficients, temperature and pressure, total capacity and performance ratio of the system under design and operating conditions. The transient nature of temperature during the seasons is modeled by ordinary differential equations based on mass and energy balance. Heat exchangers and thermo-compressor are designed based on the results of mass and energy balance. The validated model is further used to test the effect of variations in certain parameters in the process in order to investigate their influence on the total capacity of the plant. By means of parametric study, the computer simulation tool developed will help designers to achieve the best setting for the desalination process to minimize energy consumption. The comparison between the simulation results and experimental data well proves the program validity.

Keywords: Desalination; Multi-effect; Thermal vapor compression; Parametric study; Optimization

1. Introduction

The need for high quality water has significantly increased during the second half of the last century. It has been a complex task to develop an effective process without actual testing which usually requires costly test procedures. The desalination industry is very important for several countries and zones around the world, especially the countries around the Persian Gulf, such as Iran. Expansion in desalination industry is associated with reduction in power consumption. Today, thermal desalination processes account for more than 65% of the production capacity of the desalination industry [1].

The authors very strongly believe that thermal desalination processes, especially multi-effect desalination (MED), is one of the best meth-

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ods for desalting seawater to achieve very low conductivity which is very useful in power plants. For this reason, a general computer code for MED type of desalination has been developed and is currently used by a number of Iranian companies. El-Dessouky and Ettouney [2], Jernqvist et al. [3] and Ettouney [4] developed a simulation code for the MED system with shell and tube evaporators. The present work deals with both shell and tube and plate type evaporators and in addition, thermo-compressor and ejectors are designed too.

2. Mathematical modeling

A schematic of the MED–TVC system is shown in Fig. 1. The system consists of several evaporators, a condenser, and a thermo-compressor. In each effect, two phase flow inside the evaporators is modeled by mathematical equations to account the pressure drop and flow specifications [5–7].

In mathematical modeling, at first mass and energy balance equations were been developed for the system and then heat exchangers, thermo-compressor and ejectors were designed based on the results of mass and energy balance.

2.1. Mass and energy balance

2.1.1. First effect mass and energy balance

As shown in Fig. 2, the mass and energy balance for thr first effect is as follows:

$$B_1 = F_1 - D_1 \tag{1}$$

$$D_0 = S + D_r \tag{2}$$

$$X_B \cdot B_1 = X_{F_1} \cdot F \tag{3}$$

$$D_0 \times L_s = F_1 \times C_p\left(T_F, X_F\right) \times \left(T_1 - T_F\right) + D_1 \times L_1 \tag{4}$$

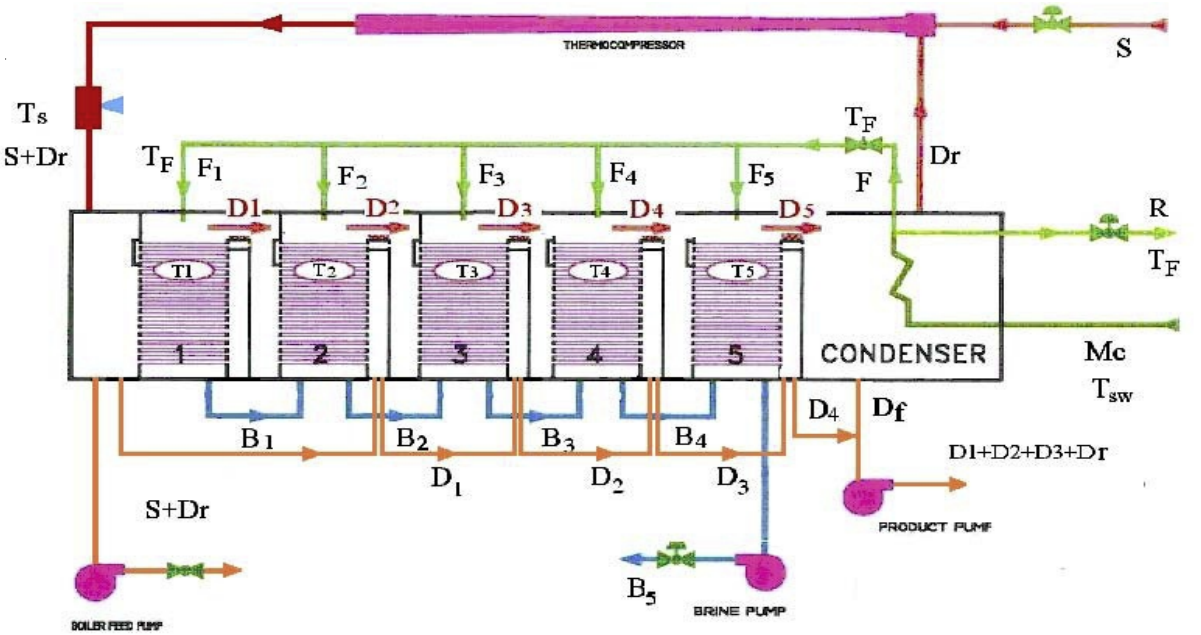

Fig. 1. Schematic of the MED–TVC system.

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