Desalination and Water Treatment
www.deswater.com

51 (2013) 983–987
January

Taylor & Francis
Taylor & Francis Group

doi: 10.1080/19443994.2012.715411

An application of dynamic simulation for 16.2 MIGD MSF desalination plant

Hyun Sung Choi*, Byoung Gu Bak, Gun Myung Lee, Sang Moon Kim, Jong Kyou Park

Water Technology Development Team, Water Business Group, Doosan Heavy Industries & Construction Co. Ltd, 22 DoosanVolvo-ro, Seongsan-Gu, Changwon, Gyeongnam, Korea
Tel. +82 55 278 3731; Fax: +82 55 278 8541; email: byounggu.bak@doosan.com

Received 2 May 2012; Accepted 18 July 2012

ABSTRACT

For several decades, multiple stage flashing (MSF) has been the main stream in thermal seawater desalination process due to its stable and robust performance. In the Middle East region, MSF units of large capacity evaporators have generally been supplied. Meanwhile, the multiple effect desalination process with thermal vapor compression has recently been receiving attention because of the lower energy consumption. Dynamic simulation of thermal desalination plant could be used to validate plant operation before and after the plant design step. Also, it is expected to be helpful for understanding the dynamic behavior of processes under various conditions. For these reasons, we have developed the dynamic simulation model for MSF using GSE's commercial package. The reference model is the Shuaibah IWPP MSF of 16.2 MIGD unit capacity (about 73,600 ton/day) in Saudi Arabia. The results showed that the simulation model was virtually stable at 100% load in summer condition with 5% deviations of designed values. In the dynamic simulation of start-up procedure, simulated trends were proven to be realistic based on real plant operation data. These results suggest that the dynamic simulation model could be applied for operator training and trouble shooting of operation procedures.

Keywords: Dynamic simulation; MSF; Cold start-up; Load change

1. Introduction

In seawater desalination, multiple stage flashing (MSF) is considered as the most widely used process because the reliability and the stability in commercial desalination plants have been proven by the operation for several decades.

In designing step of desalination plants, dynamic model will be very useful to check the overall performance and the interactions between individual components. Furthermore, it is helpful to establish the various control strategies and start-up/shut-down procedures for stable and optimum operation. It may be used for troubleshooting caused by malfunction of individual components.

This study is related to the development of 16.2 MIGD MSF dynamic simulation model and its dynamic behavior. The dynamic response of major components and the overall performance at both transient and steady state are mainly discussed in this paper.

2. Process description

The reference model of this dynamic simulation is the Shuaibah IWPP in Saudi Arabia shown in

*Corresponding author.

Presented at the International Conference on Desalination for the Environment, Clean Water and Energy, European Desalination Society, 23–26 April 2012, Barcelona, Spain

Fig. 1. The overview of Shuaibah IWPP MSF desalination plant.

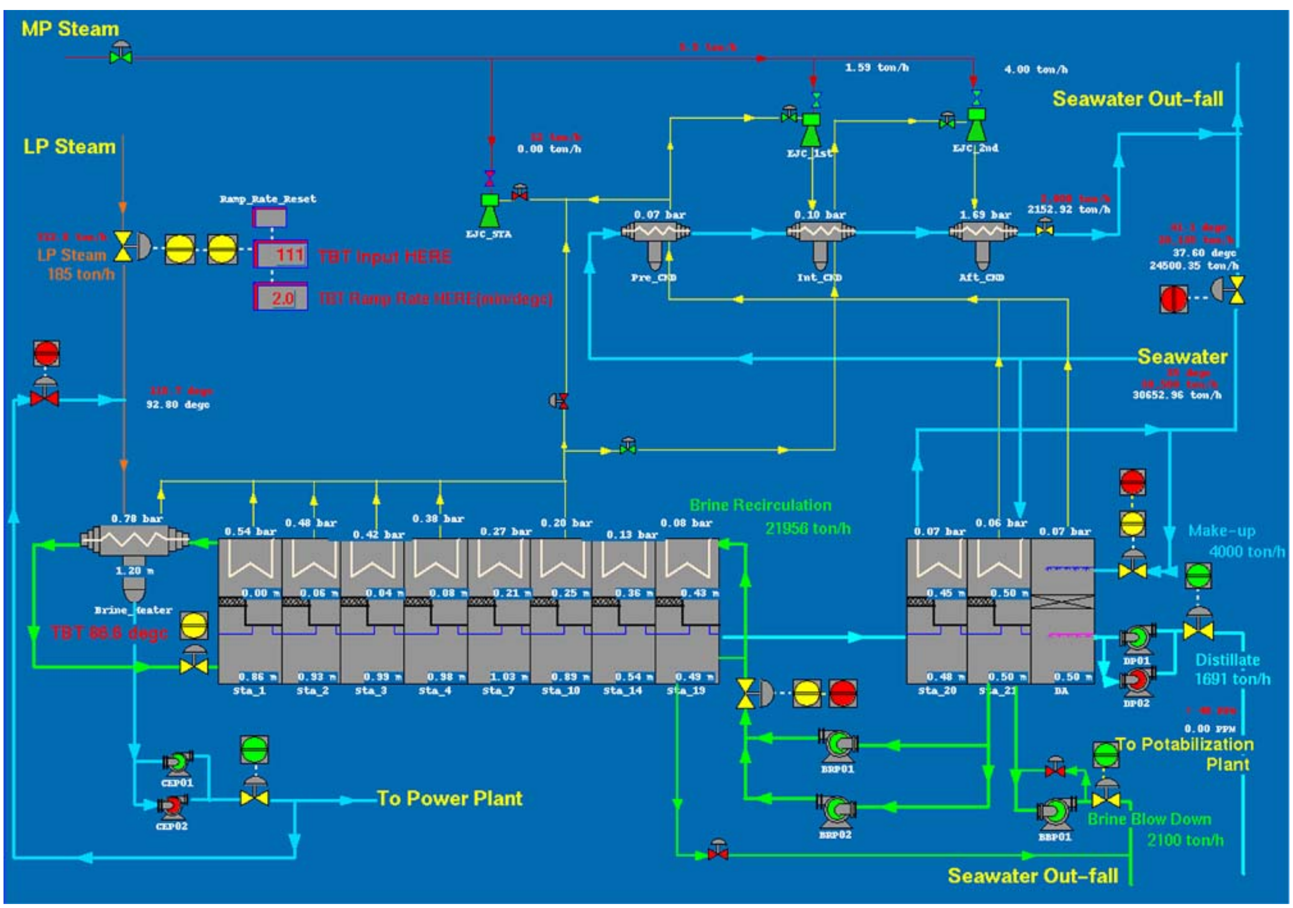

Fig. 2. The overview page of the dynamic simulation model.

Fig. 1. The total plant consists of 12 units and the capacity of each unit is 16.2 MIGD (73,600 ton/day of distillate production). As shown in Fig. 1, the power plants supply steam to MSF units as heat source.

In Fig. 2, the overview of dynamic simulation model is presented. This image was captured from the dynamic simulation tool and the major components of mechanical and control modules are displayed. The dynamic simulation model covered single unit of evaporator along with 19 stages of heat recovery section and two stages of heat rejection section and it did not include intake system, power plants, and posttreatment system. Chemical dosing system is included, but chemical reactions were not considered in this simulation model.

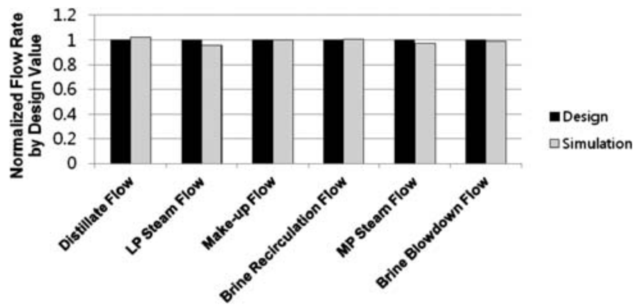

Fig. 3. The comparison of design and simulation values for major flow rates.

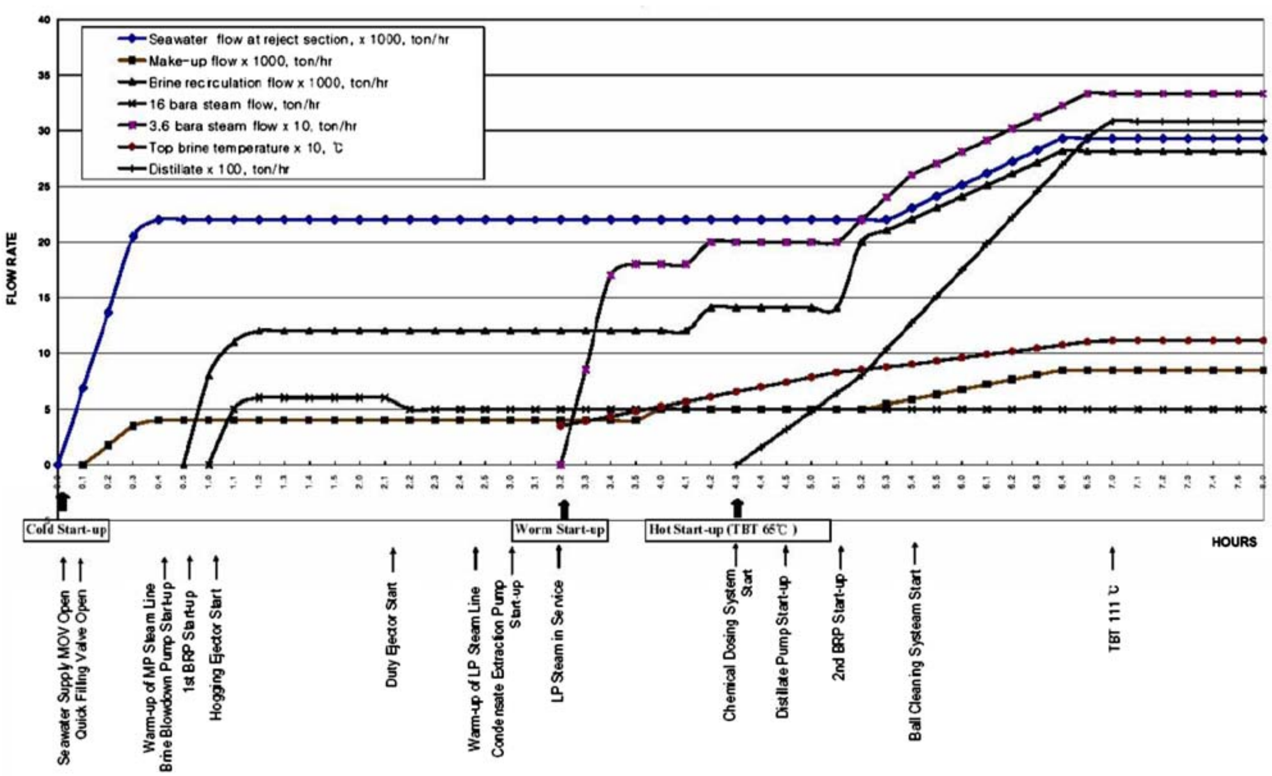

Fig. 4. The typical trend of cold start-up procedure of the real plant.

Table 1
The comparison of required time for cold start-up procedure in the real plant and dynamic simulation result

	Time (min)	
	Real plant	Dynamic simulation
Evaporators filling	46	40
Evacuation	102	110
LP steam supply to 100% load	432	380

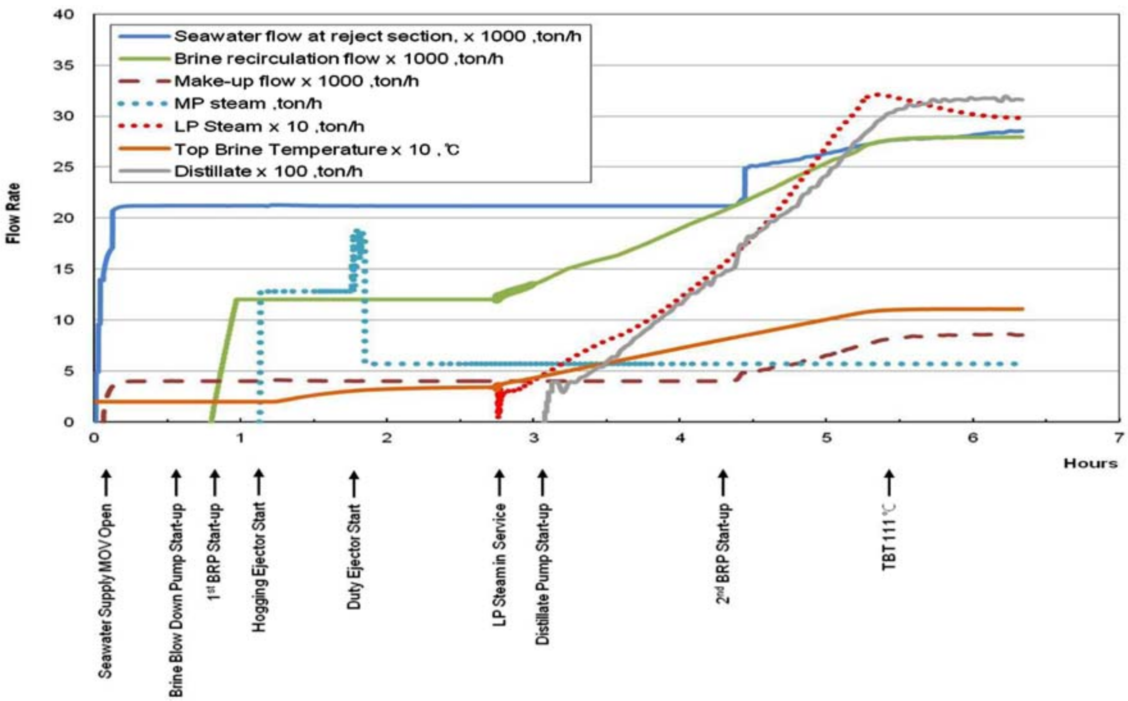

Fig. 5. The simulated trend for cold start-up procedure.

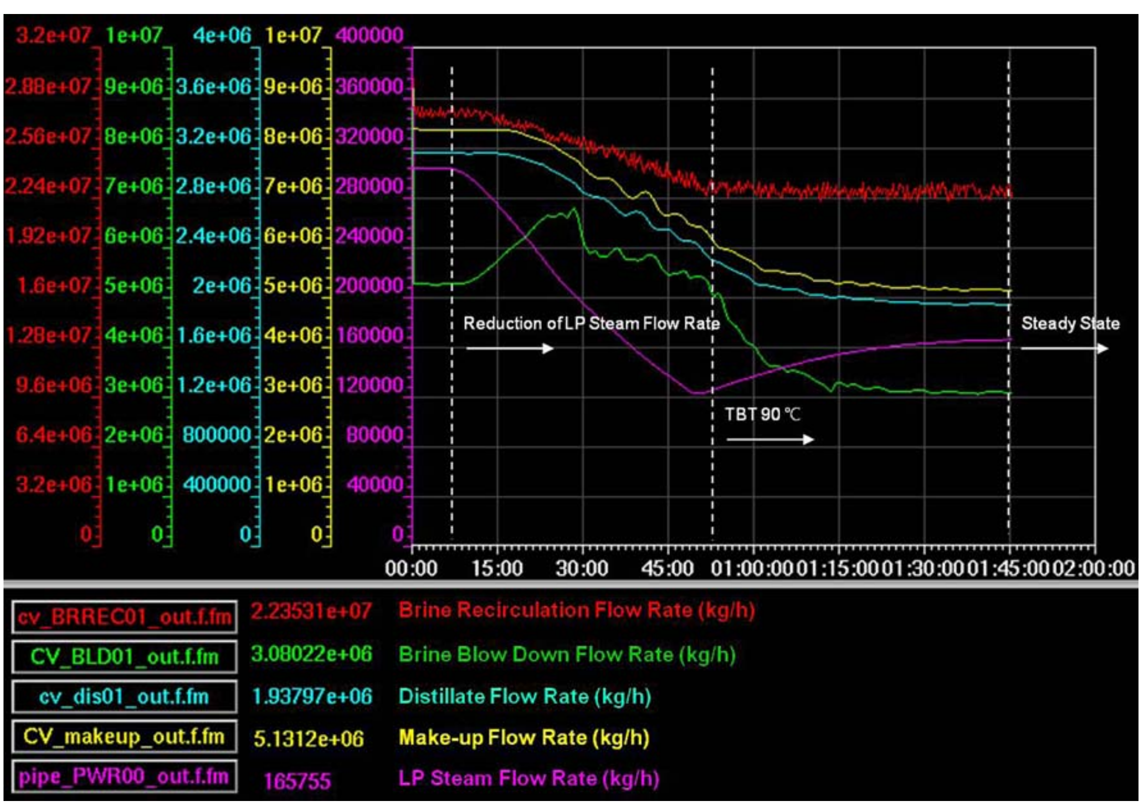

Fig. 6. The trend of mass flow rates of load change from 100 to 60%.

3. Results

The comparison of simulated and design values would be needed to evaluate the accuracy of the dynamic simulation model since the model is based on design data. In 100% load summer condition, the model was virtually stable in steady state and the deviation was 5.28%. Major flow rate of distillate, low-pressure (LP) steam, make-up, and brine recirculation and processing variables of each stage like pressure and temperature were selected to evaluate the accuracy of the simulation model. Fig. 3 shows the comparison of design and simulation values for major process flow rates.

Cold start-up procedure was composed of three substeps which were evaporator filling, evacuation, and LP steam supply. For the first step, every stage was filled with seawater and the level of each stage was maintained by start-up of brine blowdown pump. Brine recirculation pump was then started and brine recirculation flow was increased up to 40% of full load. For the next step, the pressure of evaporators and brine heater was decreased by the start-up ejector. At 0.2 barA, duty ejectors were operated and the start-up ejector was stopped. Consequently, the stage pressure lowered below 0.1 barA. Finally, LP steam from power plants was supplied to the brine heater and top brine temperature was controlled so that the temperature was gradually increased. At the same time, the brine recirculation flow was increased based on top brine temperature. After several hours, distillate production rate increased to 100% of design value. Table 1 shows the comparison of required time of cold start-up procedure in the real plant and simulation result. The simulated trend for cold start-up shown in Fig. 5 was similar to the typical trend of the real plant shown in Fig. 4.

The load change (from 100 to 60%) is similar to the reversal operation of LP steam supply step of cold start-up procedure. LP steam flow rate decreased slowly and brine recirculation flow rate also decreased in accordance with top brine temperature. After top brine temperature lowered from 110 to 90℃, it took about 50 min to achieve steady state of 60% load. Fig. 6 shows the trend of mass flow rates of load change.

4. Conclusion

The dynamic simulation model of 16.2 MIGD Shuaibah IWPP MSF was developed using commercial package. The results for the steady state showed a good agreement with design values. In 100% load summer condition, it deviated by 5% of designed values. With this model, cold start-up procedure was simulated and its trends were similar to the real plant operation data. The load change from 100 to 60% showed stable behavior and the process reached the steady state of 60% load. These results suggest that dynamic simulation model could be applied for operator training and trouble shooting of operation procedures.