SUGGESTIONS FOR FUTURE MSF-PLANT DESIGN

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Keywords : Instrumentation, Auxiliaries, Materials, Brine Recycle, Venting System

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1. Introduction

Historically, MSF desalination started with the once through mode and switched almost entirely to brine recycle about 30 years ago. There were serious reasons for this decision: the available antiscaling additives, polyphosphate and acid, were expensive and very corrosive in the case of acid if not properly dosed. Carbon steel as shell material requires very low concentrations of CO_2 and O_2 in the brine and, as a consequence, a separate very efficient deaerator/decarbonator for seawater make up.

During the past two decades, very large MSF complexes have been installed along the shores of the Arabian peninsula. With very few exceptions, these plant are characterized by

- Brine recycle operation;
- Cross flow design;
- Gain Output Ratio (GOR) of about 6-8 at a top brine temperature of = 110°C;
- Number of stages around 21;

- Double tier design;
- Carbon steel shell, cladded and/or painted;
- Copper nickel tubes and tube sheets.

Some of these plants have been in operation for more than 20 years and, due to careful maintenance, are still in good condition. This being the state of the art, one can certainly argue that new units should be built accordingly, and be larger in size. Such a decision would, however, only partially utilize the results of the world-wide intensive research in desalination, especially on materials and antiscaling additives.

Today, the situation has totally changed. Corrosion resistant materials are available at reasonable costs as well as high temperature, cost effective antiscalants. Neither with respect to corrosion nor with respect to costs is the recycle mode advantageous any more. On the contrary:

1. The recycle mode must be considered disadvantageous since it involves significantly more major pumps and valves;
2. The most essential design features of conventional cross tube brine recirculation plants will be discussed and compared to an advanced long tube once through process.

2. Key Data of Recommended Future MSF plants

The following description of the optimal future MSF plant is valid especially for large MSF plants for municipal use and based on experience and investigations on different existing plant designs along the Arabian Peninsula and the Mediterranean Sea. Figure 1 shows the principal flowsheet of the unit. Table 1 presents the main characteristics.

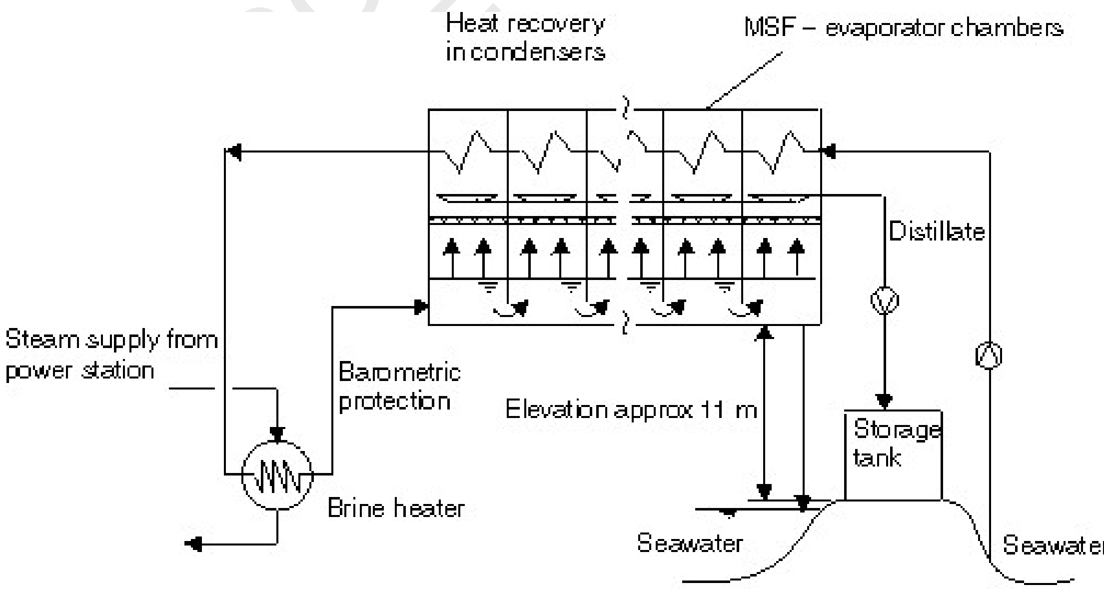

Figure 1. Future MSF - plant flowsheet.

Plant design aspects

- Once through mode instead of brine recycle, no seawater recirculation, N > 40 stages;
- Long tube instead of cross tube;
- Single tier instead of double tier;
- No blow down pump by elevation of chamber approx. 11 m above sea level;
- Hydrostatic protection against boiling in brine heater instead of
- Throttle valve by placement of heater on ground floor;
- Improved interstage orifice devices, specific weir loads up to 2000 t h^{-1} m^{-1};
- Improved condenser design without stagnant areas.

Operational aspects

- TBT > 110°C for all loads;
- Reduced partial load (max. 80-120 per cent);
- Water treatment;
- No separate deaerator, but deaeration in the first stage to atmosphere;
- No oxygen scavenger dosing;
- HT antiscalants with continous ball cleaning.

Auxiliaries

- No stand-by equipment for main pumps and valves;
- Speed control pumps eliminating control valves;
- Vent and ejector condensers as spray condensers.

Materials

- Stainless steel for evaporator shell;
- Stainless steel or titanium for tubes and tube support plates.

Table 1. Characteristics for future MSF-plants.

The key data of the MSF plant at Sirte, Lybia, are a good example of most of the features proposed, and are summarized in Table 2.

Capacity	10 000 t d^{-1} - 2.2 MGD at 118°C TBT	
GOR	10	
Long-tube design		
Once through design		
39 through design		
Shell	Solid stainless steel	1.4575 (stage 1-3) 1.4439 (stage 4-39) wall 5/6.5 mm
Tubes	Titanium Tipa16×0.5 mm	
Seawater pump	Steam turbine, variable speed	
No separate deaerator/decarbonator		
Belgard EV antiscale treatment + sponge ball cleaning		

Table 2. Key data of Sirte/Libya MSF plant.

3. Plant Design Aspects

3.1. Comparison of Brine Recycle and Once Through Mode

Comparing brine recycle and once through type plants there are several principal advantages of the once through mode which should be remembered:

1. Reduced thermodynamic losses due to lower boiling point elevation. Boiling point elevation (BPE) increases with salt concentration and temperature. Brine recycle plants operate at higher concentrations and thus higher BPE in all stages. The specific steam consumption for a typical brine recycle plant at low concentration factors (i.e high makeup ratios) is about 3 per cent higher than for a once through plant.
2. Reduced risk of calcium sulfate scaling since once through plants operate at lower concentration levels. For a top temperature of 115°C the safety margin of MSF-OT is at least three times higher compared to MSF brine recycle (see Figure 2).
3. Reduced equipment. Figure 3 shows the flow diagram of brine recycle mode for comparison with the once through mode (Figure 1).

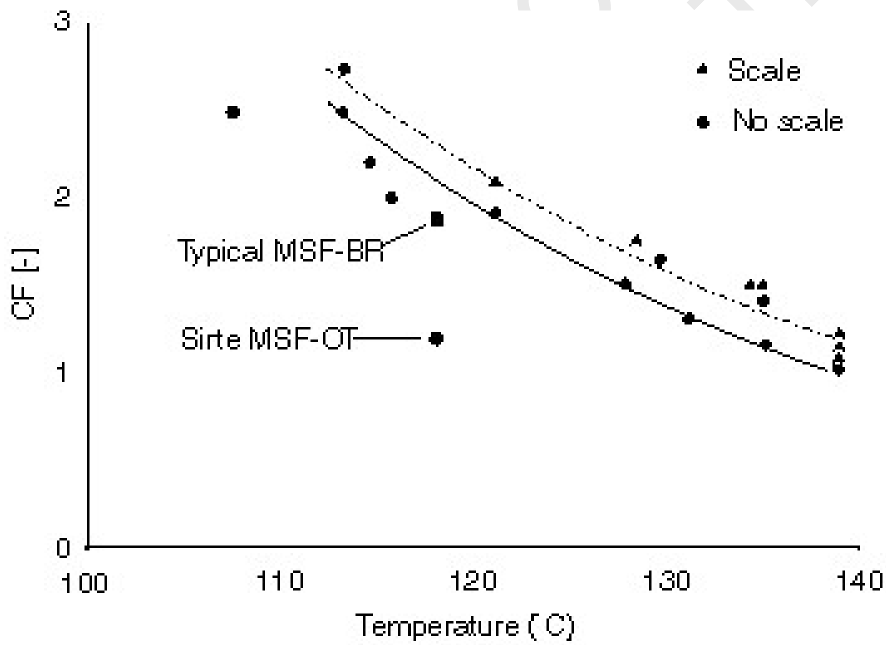

Figure 2. Operation range of once through and recycle mode with respect to calcium sulfate solubility (OSW Report 1967).

Whereas the brine recycle mode is equipped with five major pumps (brine recycle, seawater recirculation, feed, blow down and distillate), the once through mode needs only three (feed, blow down and distillate). The brine recycle pump is the largest pump operating under the most severe conditions:

- High discharge head with suction side brine close to saturation, the risk of cavitation and the expensive need to install the pump below ground level;

- Concentrated brine at temperatures above seawater temperature with the highest risk of corrosion for all pumps. Costs are about 1 per cent of total investment (including control valve but without standby).

The often-heard argument of high chemical consumption and thus significantly higher costs is incorrect as both additive prices and required dosing rates for chemicals have decreased. The long time operation of the Sirte plant could prove that once through operation requires a lower dosing rate thus compensating the water recovery rates of MSF OT.

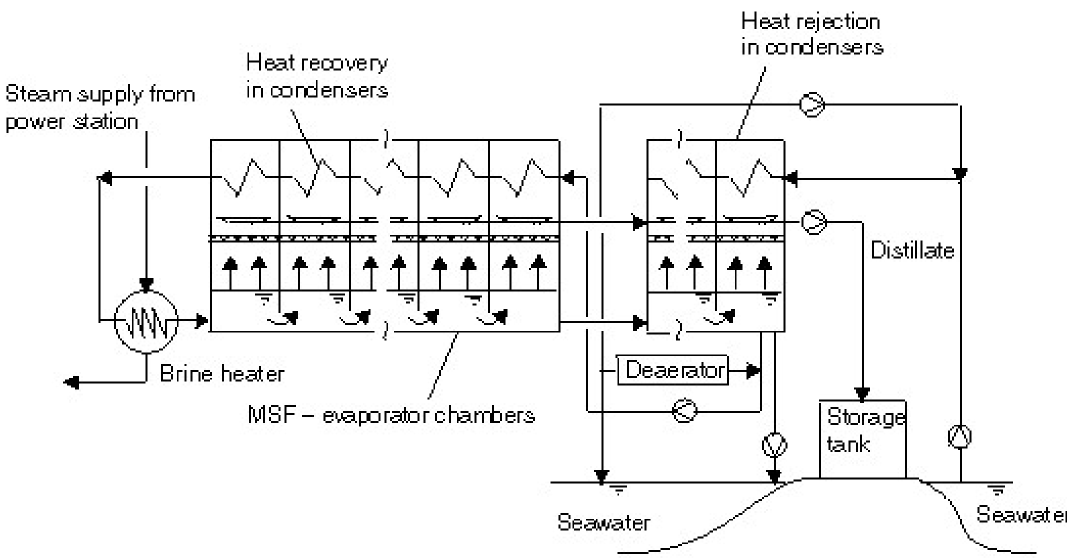

Figure 3. Conventional brine recycle MSF plant.

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Bibliography and Suggestions for further study

Akili D. Khawaji, Ibrahim K. Kutubkhanah, Jong-Mihn Wie, (2008), *Advances in seawater desalination technologies*, Desalination **221**, Elsevier, pp. 47-69.

Al Mudaiheem A M and Miyamura H (1985) Construction and commissioning of Al Jubail Phase II desalination plant. *Desalination* 55, 1-11.

Babcock Deutsche Babcock AG (1994) *Optimisation for maintenance and operation of desalination plants in Abu Dhabi* Report, VIII Deutsche Babcock in cooperation with University Aachen, University Bremen, Todd and Associates, Wangnick Consulting, Germany.

Babcock Deutsche Babcock AG (1995) *Optimisation for maintenance and operation of desalination plants in Abu Dhabi - Control strategy improvement*, Report VIII Deutsche Babcock in cooperation with University Aachen, University Bremen, Todd and Associates, Wangnick Consulting, Germany.

Babcock Deutsche Babcock AG (1996) *Solving of malfunctions, hazards and maintenance problems in existing desalination plants in Abu Dhabi* Report II Deutsche Babcock in cooperation with University Aachen, University Bremen, Todd and Associates, Wangnick Consulting, Germany.

Corrado Sommariva ,(2010),COURSES IN DESALINATION, Thermal Desalination

Hanbury W T (1993) Some thoughts on the limitations on increasing the unit size of conventional cross tube MSF distillation plants. *Desalination* 93, 127-145.

Hisham El-Dessouky, S. Bingulac, (1995), *A Stage-by-Stage Algorithm for Solving the Steady State Model of Multi-Stage Flash Desalination Plants*, IDA 141, Volume **IV**, pp. 251-27.

Joachim Gebel, Süleyman Yüce, (2008), *A new approach to meet the growing demand of professional training for the operating and management staff of desalination plants*, Desalination **220**, Elsevier, pp. 150-164.

M.A. Darwish , Iain McGregor, (2005), *Five days' Intensive Course on - Thermal Desalination Processes Fundamentals and Practice*, MEDRC & Water Research Center Sultan Qaboos University, Oman

M.A. Darwish, Ammar Alsairafi, (2004), *Technical comparison between TVC/MED and MSF*, Desalination **170**, Elsevier, pp. 223-239.

M.A. Darwish, Hassan K. Abdulrahim, (2008), *Feed water arrangements in a multi-effect desalting system*, Desalination **228**, Elsevier, pp. 30-54.

M.A. Darwish, N. Al-Najem, N. Lior, (2006), *Towards Sustainable Energy in Seawater Desalting in the Gulf Area*, Tenth International Water Technology Conference, Alexandria, Egypt, pp. 655-684.

Mohamed A. Dawoud, (2005), *The role of desalination in augmentation of water supply in GCC countries*, Desalination **186**, Elsevier, pp. 187-198.

Mohamed Al-bahou, Zamzam Al-Rakaf, Hassan Zaki, Hisham Ettouney, (2007), *Desalination experience in Kuwait*, Desalination **204**, Elsevier, pp. 403-415.

Nabil M. Abdel-Jabbar, Hazim Mohameed Qiblawey, Farouq S. Mjalli, Hisham Ettouney, (2007), *Simulation of large capacity MSF brine circulation plants*, Desalination **204**, Elsevier, pp. 501-514.

OSW-Res. (1967) (Office of Saline Water), Develop. Progress. Report, No. 288 (1967), Cal. USA.

Rautenbach R, Schafer S and Schleiden S (1996) Improved equation for the calculation of non equilibrium losses in MSF. *Desalination* 108, 325-333.

Rautenbach R, Widua J and Schafer S (1995) Reflections on desalination processes for the 21st Century. IDA World Congress on "Desalination and Water Reuse", Abu Dhabi, vol. 1, 117.

Roberton Borsani, Silvio Rebagliati (2005), Fundamentals and costing of MSF desalination plants and comparison with other technologies, Desalination 182, Elsevier, pp. 29-37.

Semiat, R., 2000. Desalination – present and Future. Water International, 25(1), 54-65.

Spiegler, K.S. and El-Sayed, Y.M., 1994. A Desalination Primer. Balaban Desalination Publications, Santa Maria Imbaro, Italy.

Tusel G F and Kamal I (1981) Analysis of water and power costs by various methods, based on Jeddah IV. *Desalination* 38, 145.

Tusel G F, Rautenbach R and Widua J (1994) Seawater desalination plant "Sirte" - an example of an advanced MSF design. *Desalination* 96, 379-396.

Y.M. El-Sayed, (2001), *Designing desalination systems for higher productivity*, Desalination **134**, Elsevier, pp. 129-158