الدورة 12
مؤتمر تحلية المياه في الدول العربية
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فندق انتركونتيننتال سيتي ستارز، القاهرة، جمهورية مصر العربية
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Effect of Increasing Top Brine Temperature on MED-FF Systems

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| OUTLINES

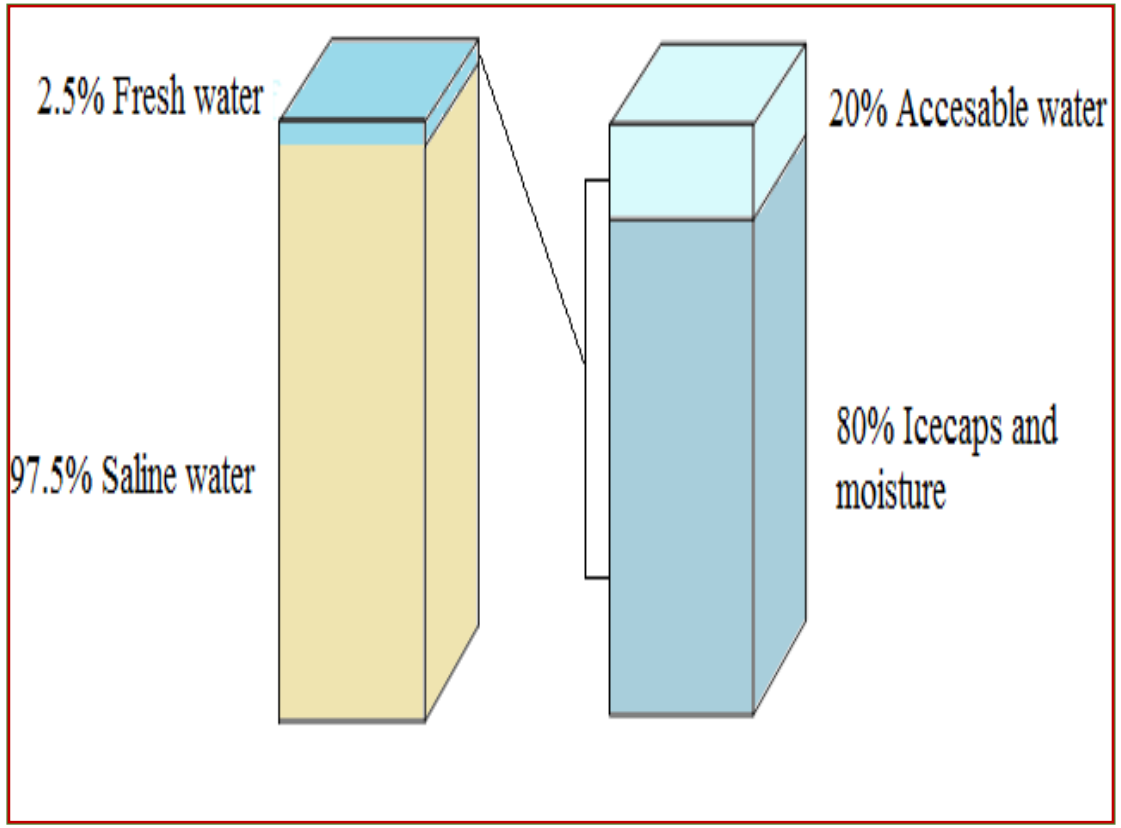
1. INTRODUCTION
2. LIMITATION
3. WAYS TO OVERCOME THE LIMITATION
4. MODEL
5. RESULTS
6. CONCLUSION

Courtesy from Mr. Awrebach, Dean, IDA Desalination Academy

INTRODUCTION

NEED FOR WATER FOR WATER DESALINATION

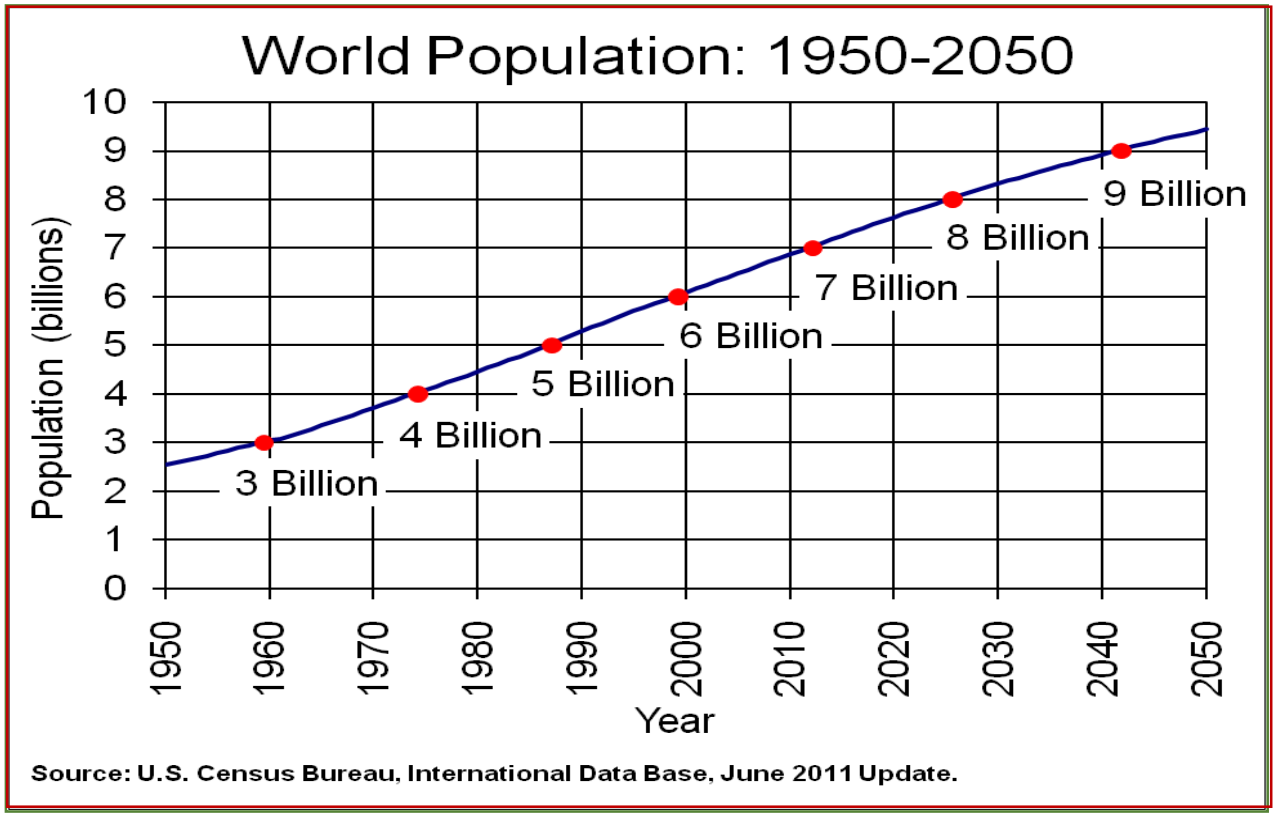
- The volume of the water available in the earth is 1.4 10^9 Km^3 covers 70% of the earth surface area.
- 97.5 % of this water is salt water
- 80 % of the rest is frozen in the icecaps or combined as a soil moisture
- The remaining quantity which is (20% of 2.5% = 0.5 %) of the total quantity available in the earth used to support the live in our planet



INTRODUCTION

NEED FOR WATER DESALINATION

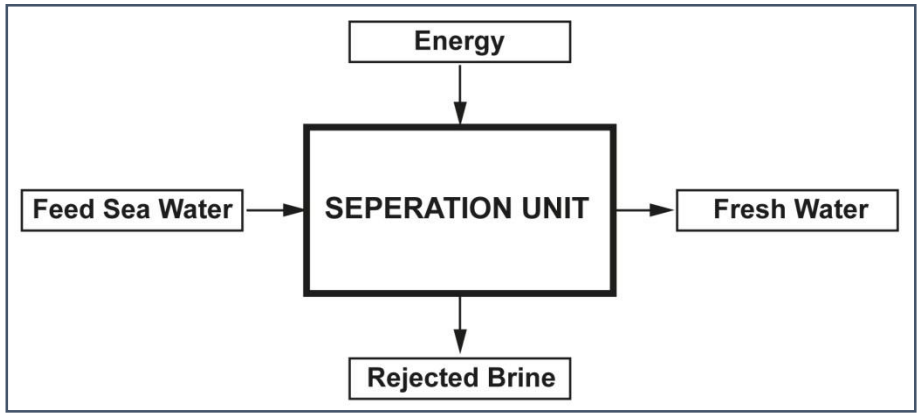
- The water quantity is almost constant
- The population is increasing significantly



INTRODUCTION

Definition of desalination processes

- Desalination process is a process of separation of fresh water from saline water
- Desalination process based on thermal or membrane separation .



Thermal Separation Include

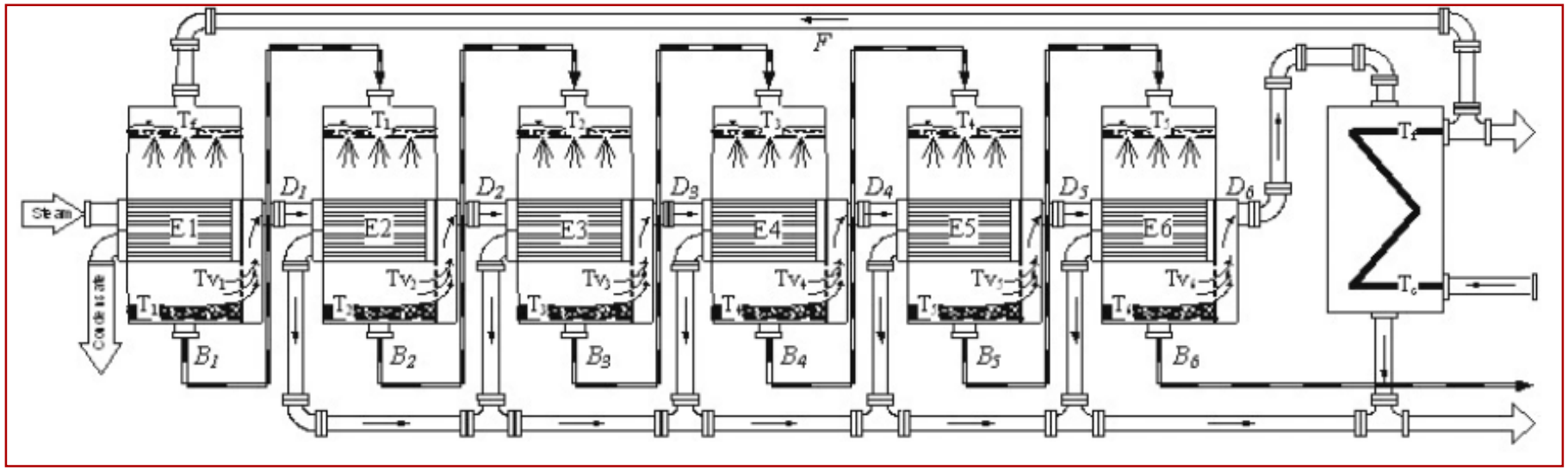
- Evaporation followed be condensation (MSF, MED, HDH)
- Freezing followed by melting

The membrane separation include

- Reverse osmosis (RO)
- Electro dialysis (ED)

INTRODUCTION

Multi effect evaporation system Developments-FF



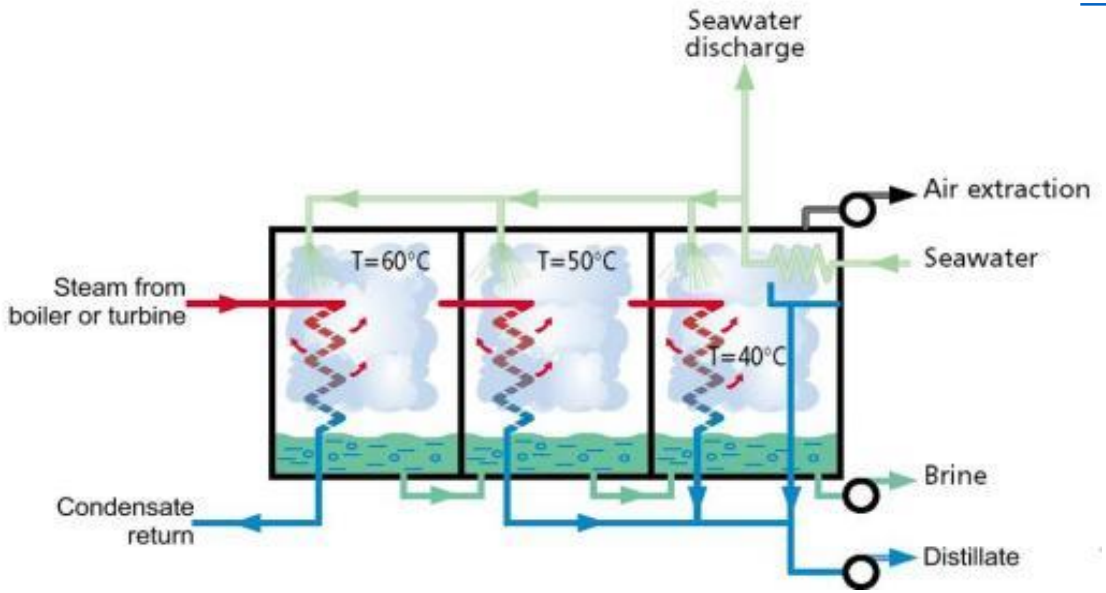
Darwish* and Abdulrahim Feed water arrangement in multi effect desalination systems

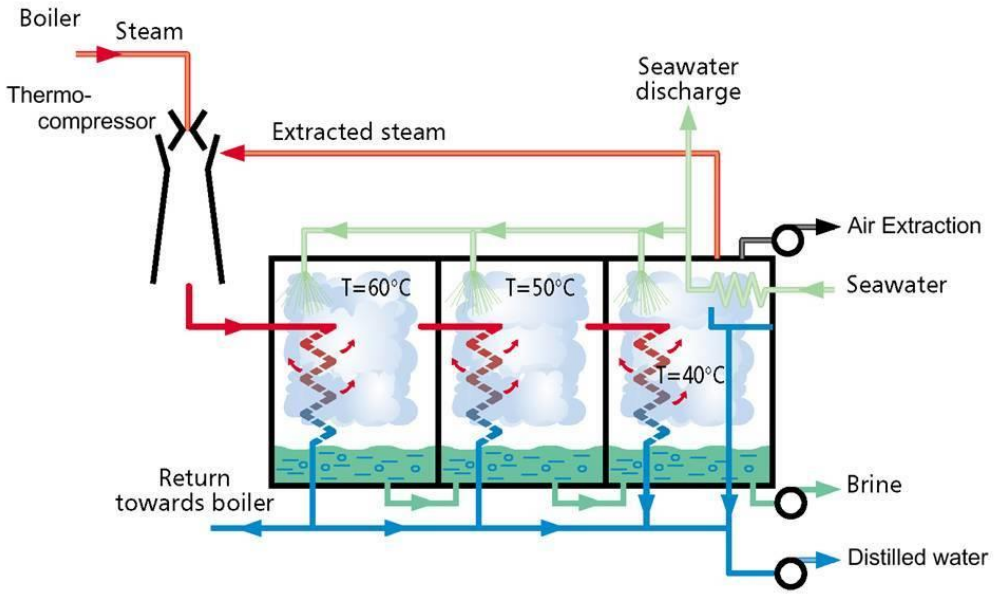
- It is a formed a sequence of single effect evaporators
- The vapor created in the first effect is used as a source of heat in the next effect
- Avoid rejection of heated brine , which was the main drawback of the single effect system

INTRODUCTION

Multi effect evaporation system Developments- PCF

http://www.sidem-desalination.com/en/process/MED/Process/





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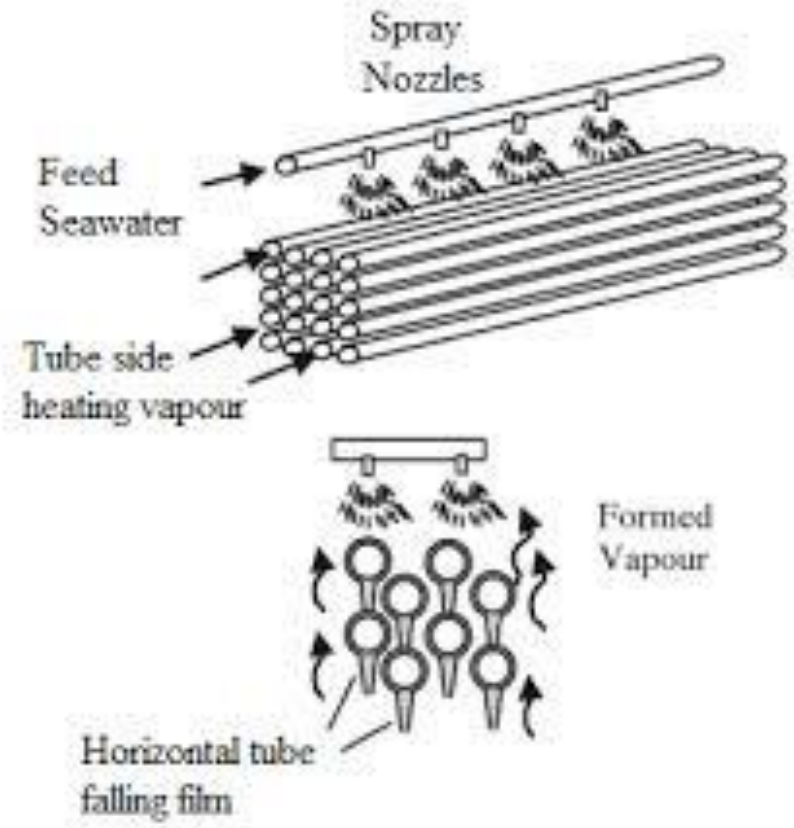
ENERGY REQUIREMENT

Process/energy type	MED	MED -TVC	MSF	RO
Specific heat consumption, kJ/kg, PR kg/2326 kJ/kg	178 13	221-250 11.0-9.3	250-273 9.3-8.5	
Steam pressure, ata	0.3 - 0.4	2.5-3.5	2.5-3.5	_
Electric energy equivalent, kWh/m^3	3-4.5	5.4-8*	5.6-8.0	_
Electric consumption, kWh/m^3	1.0--1.5	0.9-1.8	3.4-4.5	3.3-4.0
Total electric energy equivalent, kWh/m^3	4.0-5.0	6.3-9.8	9.0-12.5	3.3-4.0

Courtesy from Mr. Awrebach, Dean, IDA Desalination Academy

LIMITATION

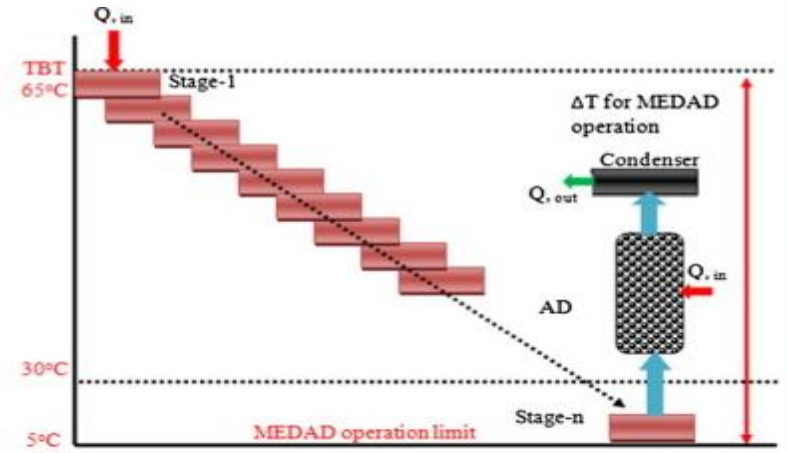
- Since seawater is sprayed outside the tube bundle surface of each effect, the top brine temperature TBT in MED technology I is limited to a typical value of 65°C.
- The seawater temperature is about 25-30 °C. This means that rejected brine temperature may be about 40°C.
- Therefore, this technology has a limited flashing range.



http://www.arpnjournals.org/jeas/research_papers/rp_2017/jeas_0517_6008.pdf

To Overcome the Limitation

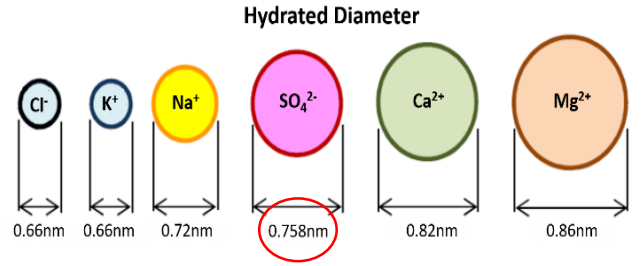
- Decreasing the low temperature side (Rejected Brine Temperature)
  - A group of scientists in KAUST (Kim Choon Ng and associates) extended the flashing range by connecting the MED unit to an adsorption system to a low temperature of about 5°C (MEDAD).
  - This leads to more effects, more evaporation and higher PR.

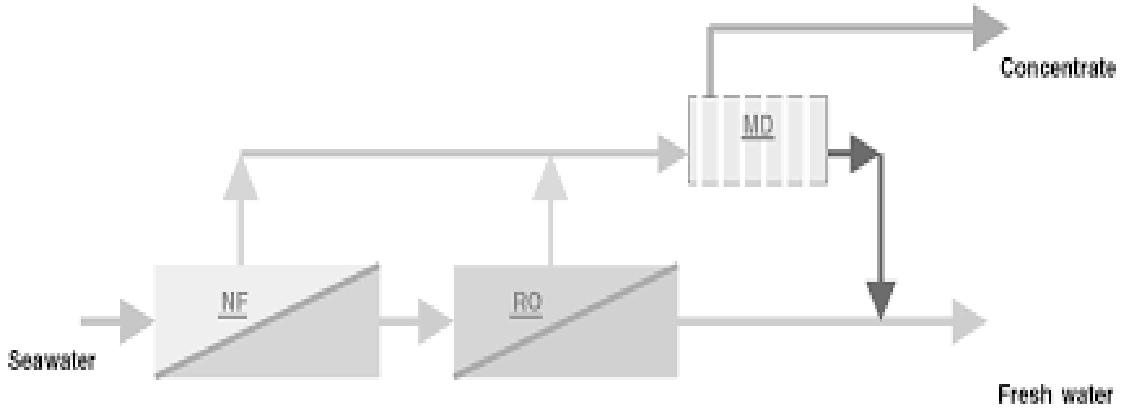


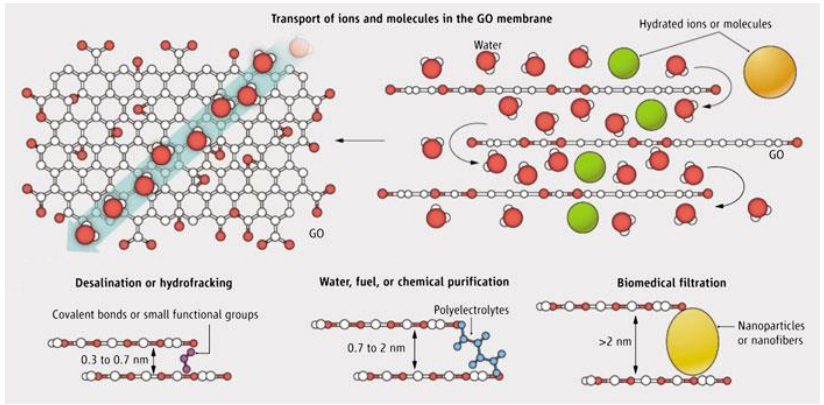
M. W. Shahzad **et al., An experimental investigation on MEDAD hybrid desalination cycle, Applied Energy, Applied Energy, Volume 148, 15 June 2015, Pages 273-281**

To Overcome the Limitation

- Increasing the top brine temperature (TBT) in MSF systems leads to a similar effect of expanding the flashing range.
- This can be achieved safely if the divalent ions are removed from the feed seawater.
  - Nano Filtration
  - Coating membranes (UF) with reduced GO

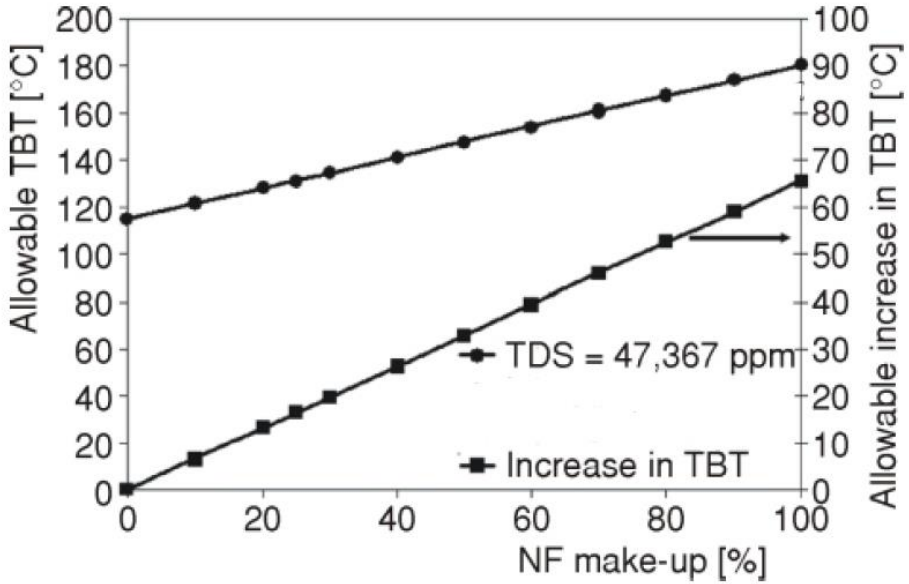






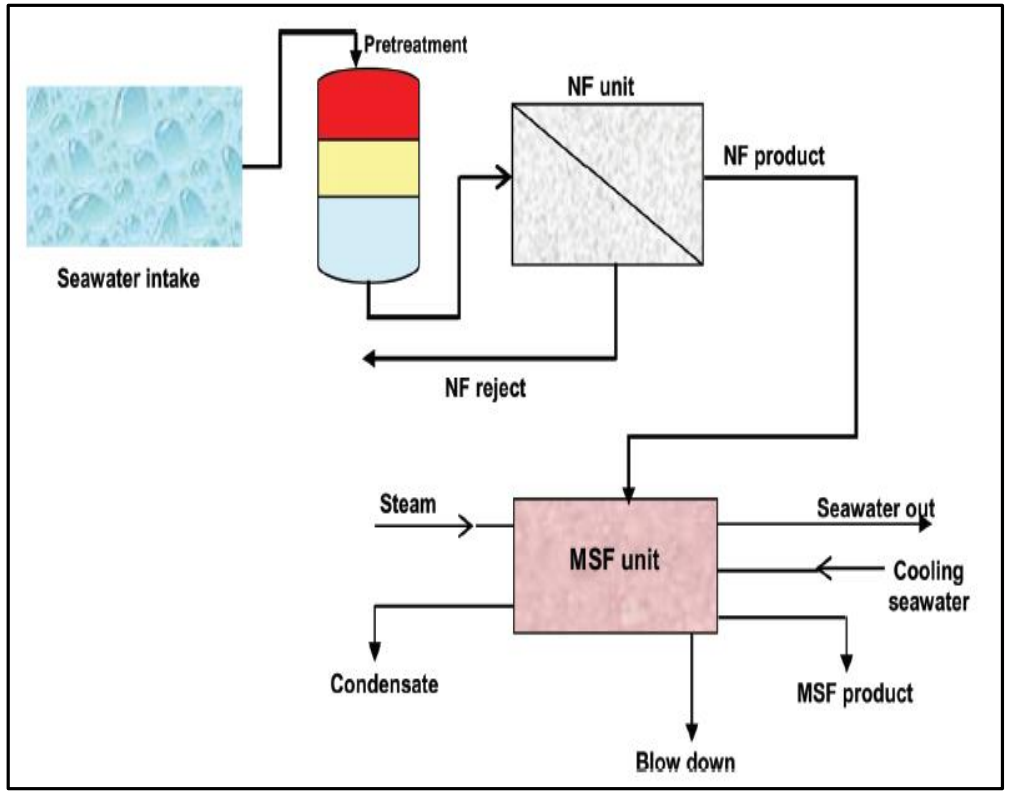
Nano Filtration

- Al-Rawajfeh studied the influence of NF pretreatment on scale formation in (MSF) desalination systems.
- The NF rejection and permeate flow rates were simulated by the IMS software (by Hydranautics Nitto Denko Company).
- The TBT can be increased up to 170°C at 100% NF pretreatment.



Nano Filtration

- The performance of the NF membrane as a pretreatment for MSF desalination processes was also studied by another group from SWCC
- The feed pressure was varied from 20 to 40 bar.
- For the first 34 days, the MSF was operated at a TBT of 120°C without using anti-scalants and no scale formation occurred.
- The MSF was then operated for 50 days at a TBT of 130°C. No scaling issues were observed. (additives were used)



RGO coating

Bassel Abdel Kader et al. objectives

- GO/PAM-PES membrane is prepared via spin coating then reduced to 2rGO/PAM-PES
- NF270 and rGO membranes are tested in a cross-flow test with $MgSO_4$, $CaSO_4$ and seawater
- 2rGO/PAM-PES (or UF membrane coated with rGO) and NF membranes yield a similar rejection rate
- 2rGO/PAM-PES membrane yield the highest TBT without scaling for MS
- The TBT can be increased to 148^0C using NF, 160^0C using NF-GO and 166^0C using rGO membrane

So, it is possible

Increasing TBT in MSF-OT Systems

Yagnaseni Roy et al.

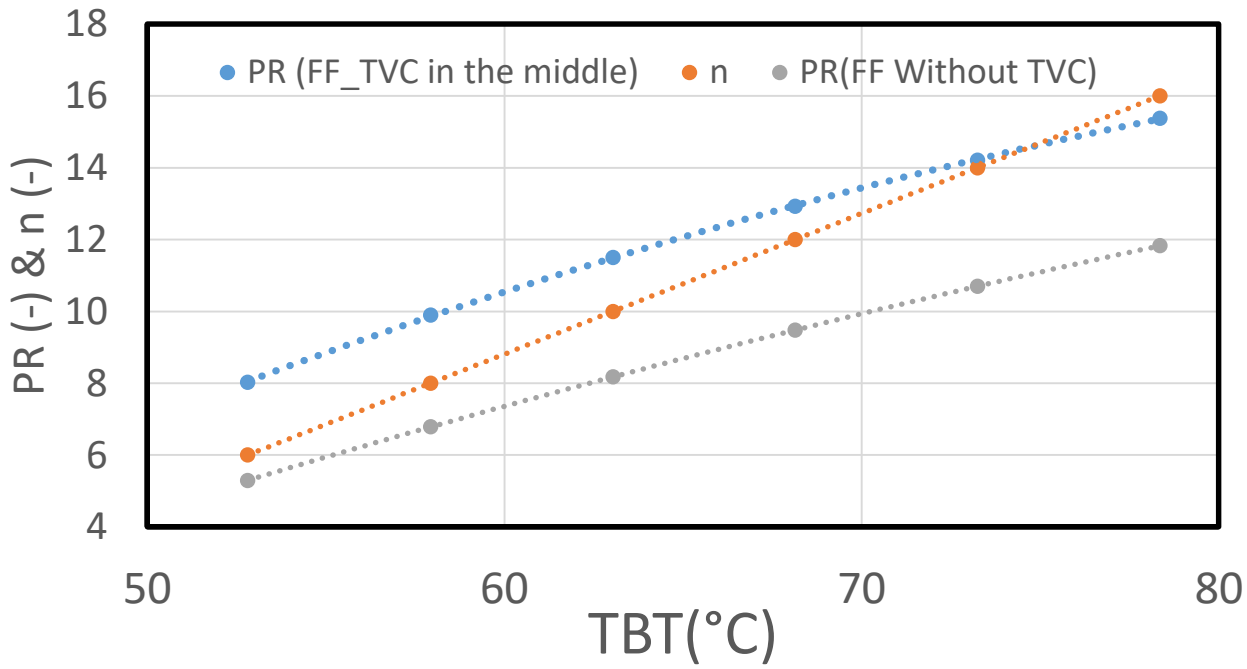
- It was shown that there is potential to improve the PR of the existing Sirte plant in Libya by increasing the TBT to 160^{o}C, keeping all other operational conditions unchanged.
- At this TBT, PR is expected to increase by 56% from the existing value to 15.6.
- The sA requirement increased by 7.69 %, showing that the penalty of sA requirement is relatively small.
- They also studied the effect of decreasing T_n that shows significant improvement.

Model

- A mathematical model was developed for MED-FF for both MED-FF and MED-FF with TVC.
- The optimum condition of TVC location at n/2 (proved in a previous paper) is considered for the MED-FF model with TVC.
- The model is based on Mass Conservation and Energy equation for all system components.
- Power model is used for TVC system modelling.
- The model was validated against existing models in the literature where a maximum difference of 0.5 % was reported.

RESULTS

- Increasing the TBT increases the flashing range and accordingly leads to the use of a higher number of effects.
- Rising the TBT from 65 to 78 C rises the number of evaporators from 8 to 16.
- It increases the performance ratio for MED and MED-TVC by 123 % and 91% , respectively.



Influence of increasing (TBT) on n and PR for MED FF system

RESULTS

- Adding more effects would naturally be accompanied with an increase in the heat transfer area due to the addition of more tube bundles.
- But, the productivity increases significantly
- The figure shows a smaller rate of increase such that the percentage increase for the case without a TVC and after adding the TVC are 24 % and 26%, respectively.

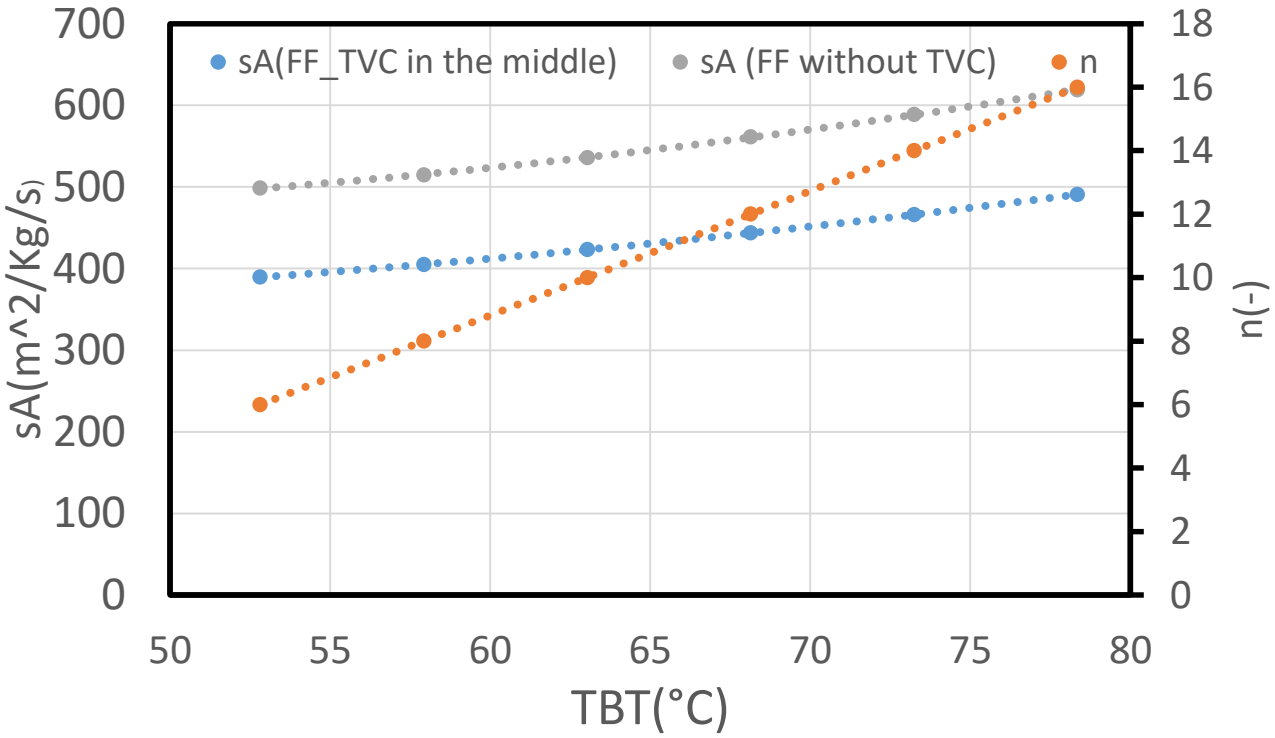
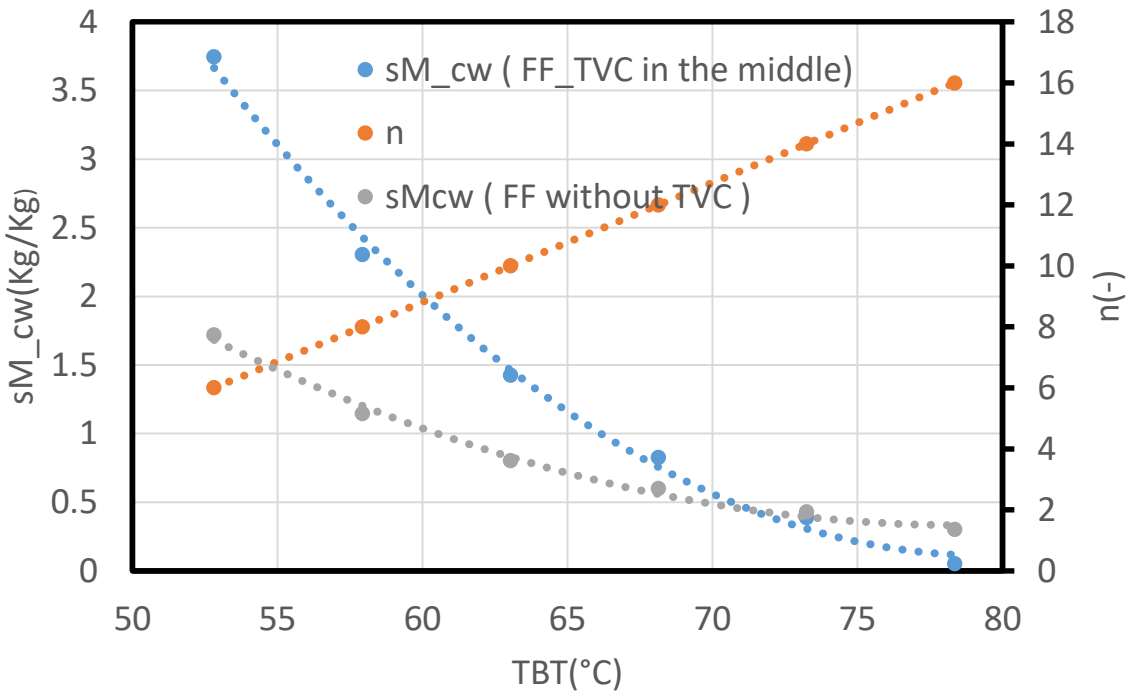


Figure 4: Effect of increasing (TBT) on n and sA for MED-FF system

RESULTS

- Increasing the top brine temperature results in an increase in the specific mass flowrate of the cooling seawater.
- the effect of the increase in the rate of productivity outweighs the seawater flowrate increase leading to reduces “normalized” value of the specific mass flowrate.
- The decrease is quantified to vary from 7.74 to 1.35 for a MED-FF system without TVC whereas it varies from 3.7 to 0.051 for a MED-FF system with TVC.



Effect of increasing (TBT) on n and sM_{cw} for MED-FF system

CONCLUSION

- Increasing TBT provides an opportunity to increase the number of effects to generate more vapor and higher performance ratio.
- For instance, rising the TBT from 65 to 78 ^{o}C results in increasing the number of effects from 8 to 16 and increases the performance ratio of MED-FF system significantly while the penalty in terms of the increasing the specific heat transfer area is about 25%.
- Another outcome of this change is represented in terms of the lower specific mass flow rate of cooling water needed to condense the vapor that is formed in the last effect.

THANK YOU