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تحت رعاية معالي رئيس مجلس الوزراء المصري المهندس شريف إسماعيل
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Parallel Feed MED-MVC System Improved Performance

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بالتعاون مع
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Introduction

- Water shortage is related to enormous rise in population and the vastly increasing industrialization.
- Thermal desalination systems mimic the water natural cycle in the earth → evaporation and condensation
- The heat required (Steam) for evaporation is recovered during the condensing process.

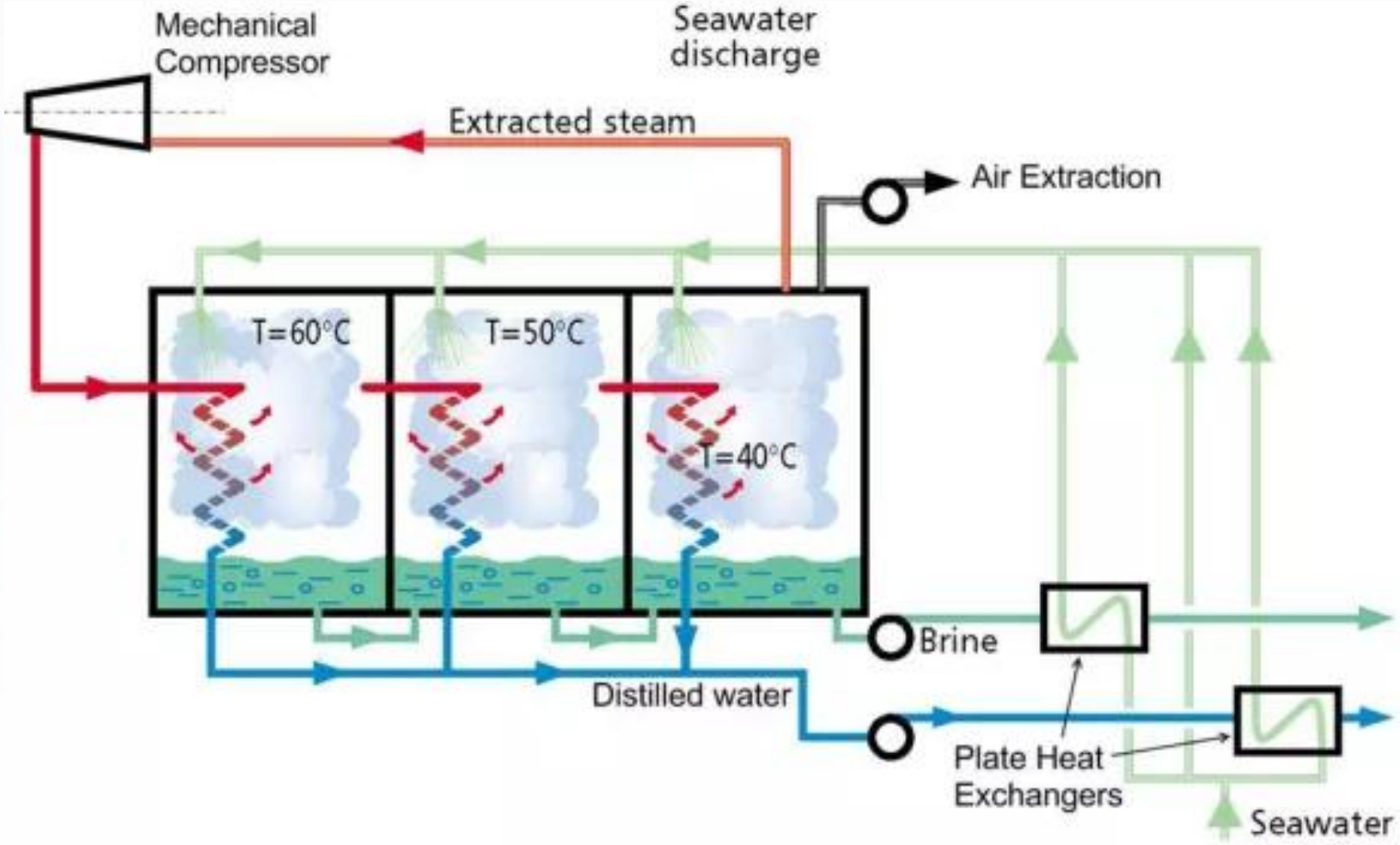
Introduction

- Multi-effect Desalination (MED) is a type of evaporation with many economic and technical advantages.
- Seawater is heated to a top brine temperature that is limited to 60 or 65^{o}C to avoid scaling on the outside surface of tubes (unlike MSF).
- The formed vapor in one effect is taken to the next effect to condense inside the tubes releasing heat (latent)

Introduction

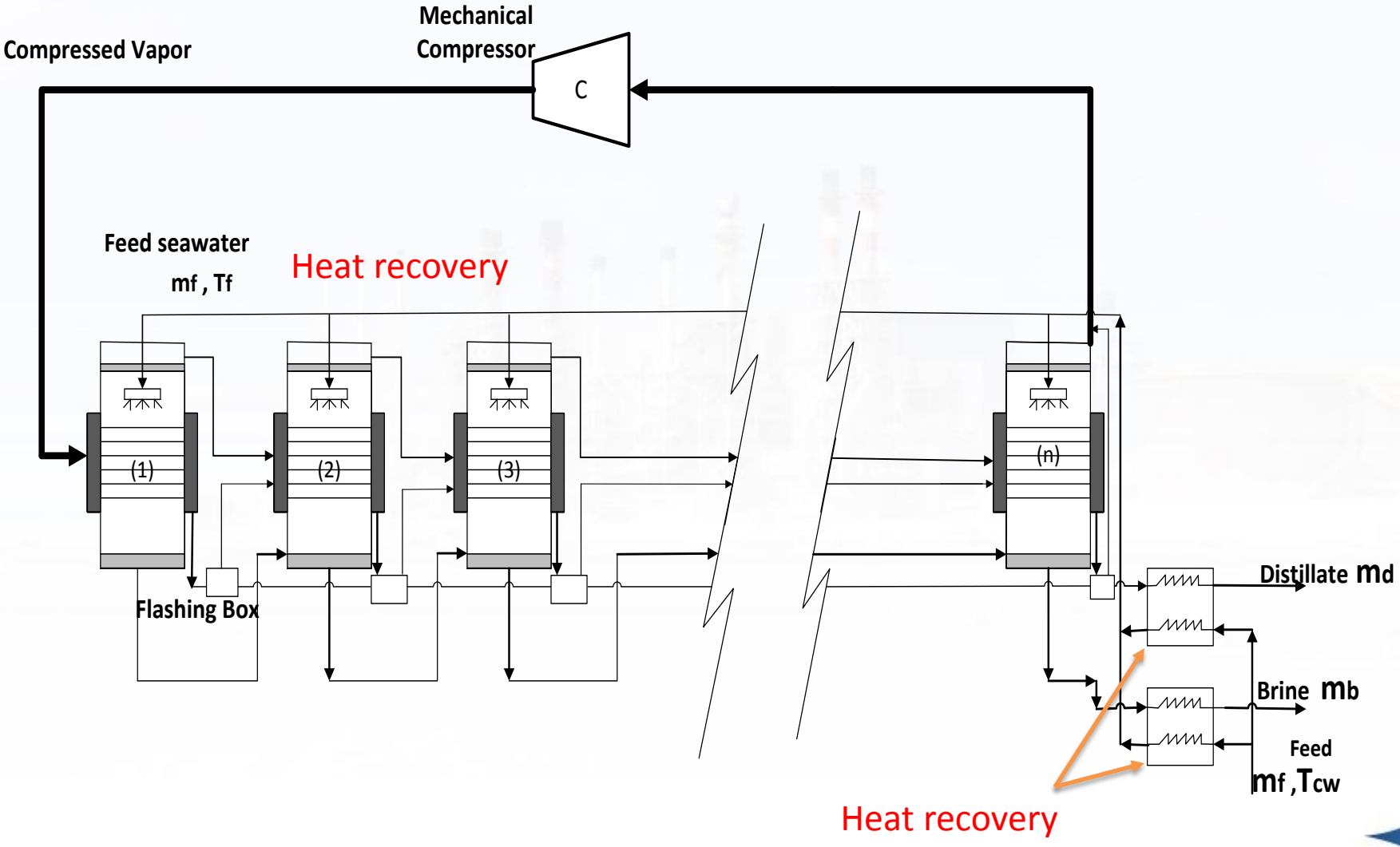
- The vapor formed in the last effect is the input to a compressor where is it compressed to higher P (and T) to be used as heat source to the first effect.

Introduction



http://www.sidem-desalination.com/zoom?media=zoomimg&doc=26716&id=c12238873151-img&src=kit_vwst_rwd

Introduction



WHY MED-MVC

- Compact
- Independent of an external heating source.
- Therefore, they are suitable for remote areas (no power plants, no boilers.
- The mechanical power can be provided either by electric energy or through a diesel engine. (wind….)

Existing Systems

- Berrup, Peninsula (Australia)
  Capacity: 3,600 m^3/d, process water (69^oC)
- CHP, Taba (Egypt)
  Capacity: 2,000 m^3/d, potable water

Source: http://www.wabag.com/performance-range/processes-and-technologies/mvc-mechanical-vapour-compression/

- MED-MVC - 2 units of 500 m^3/day (1,000 cubic meters daily production) In Al Ghalilah - Sultanate of Oman.
- Energy Consumption has improved from 16 kWh/m^3 in 1975 to 6.9 kWh/m^3 in 1995 to 5.2 (Expected) with a foreseen capacity of 5000 m^3/day.

State of the Art

Authors	Study	Results
HAMED et al. [1996]	MED-MVC and MED-TVC for 4 effects	They reported that the MED-TVC system is more efficient than MED-MVC system.
El- Dessouky et al. [2000]	MED-MVC (P & PC).	The specific power consumption for MED-MVC parallel cross is lower than MED-MVC parallel feed.
Bahar et al. [2004]	MED-MVC.	Results showed that the brine concentration rate affects the distillate flow rate.

State of the Art

Authors	Study	Results
Ophir et al. [2007]	MED with turbo-compressor at low temperature.	An auxiliary turbine and a compressor of higher efficiency than thermo-compressor results in considerable energy savings.
Lara et al. [2008]	MVC system operating at high temperature	At high temperature, heat transfer area is small, compression work is low. They used a small compressor to reduce the capital cost.
Fuad et al. [2011]	The effect of stage temperature drop on MED-MVC	The specific power consumption decreases as MVC brine temperature increase, and volume flow rate is decreased as MVC brine temperature increase.

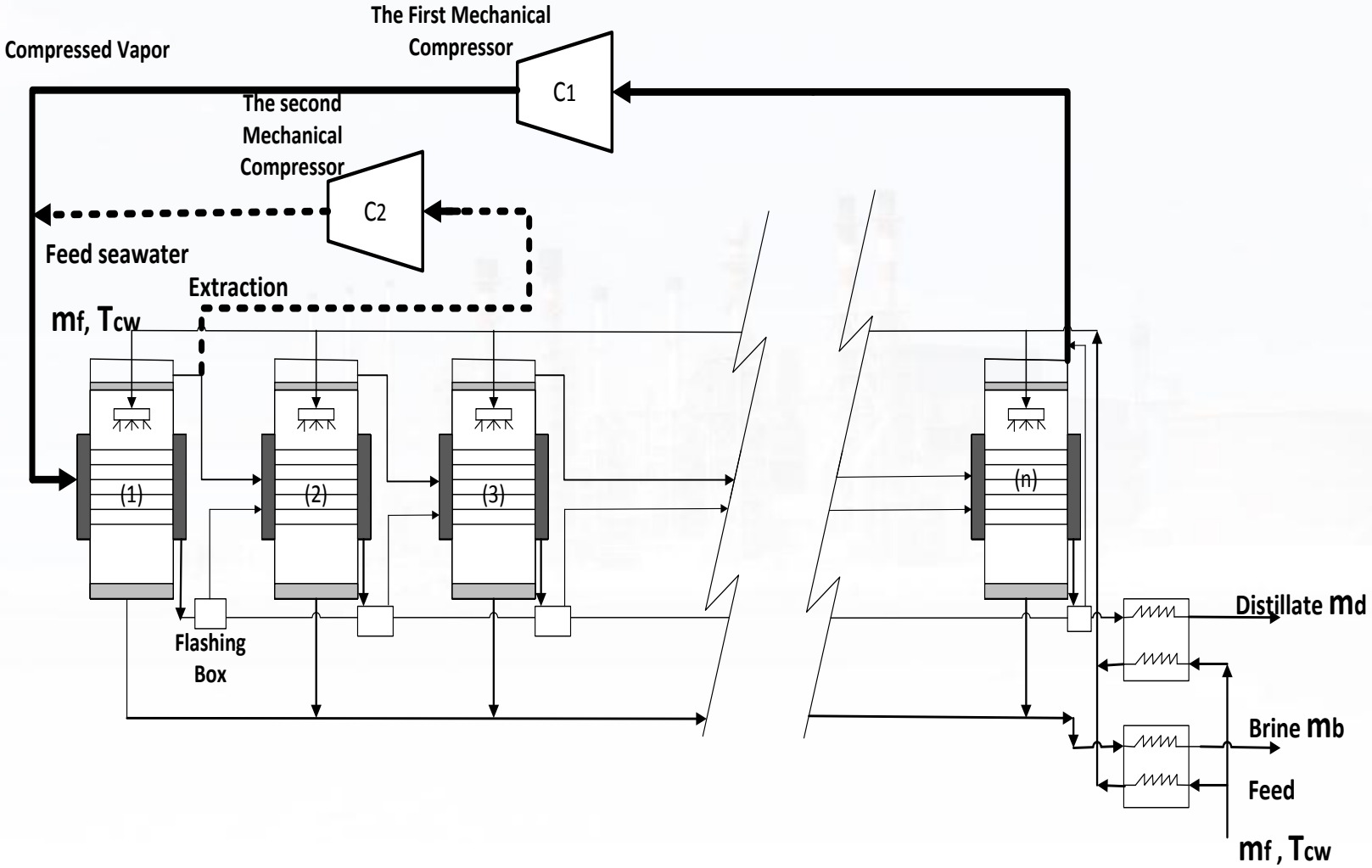
What is new

- Adding a smaller, secondary compressor
- It extracts formed vapor from one of the effects of a MED-MVC system
- It compresses it to the state of vapor that enters the first effect as a heat source (additional)
- It generated more vapor int eh first effect and the other effects as well
- Does it justify the additional power and cost??

What is new

- This addition improves the system performance through
  - Effective heating of the sprayed seawater in the first effect
  - Generating more vapor that may eventually increase the system productivity
  - Reduced specific power consumption
- Is there a best location for secondary compressor??

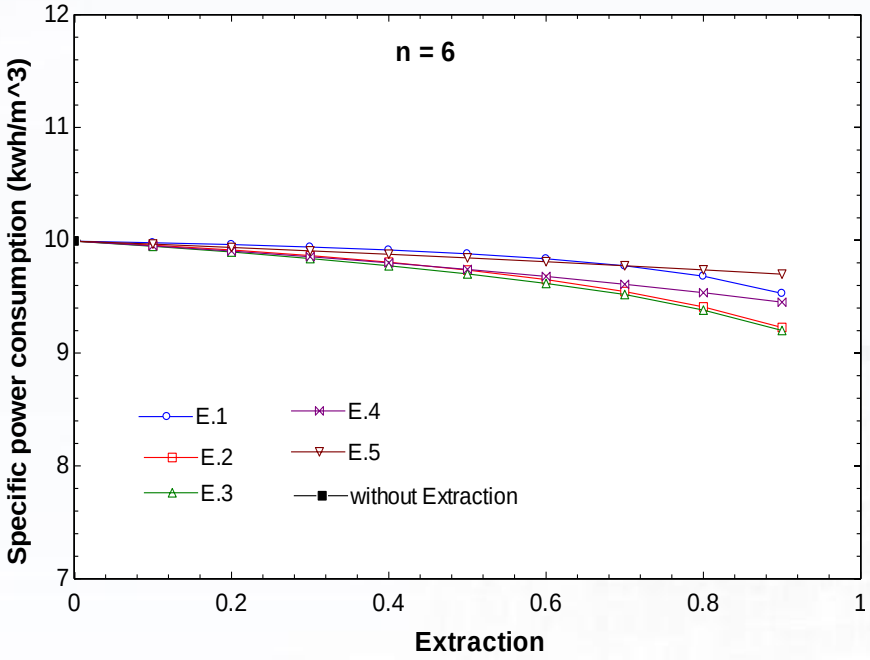
New system

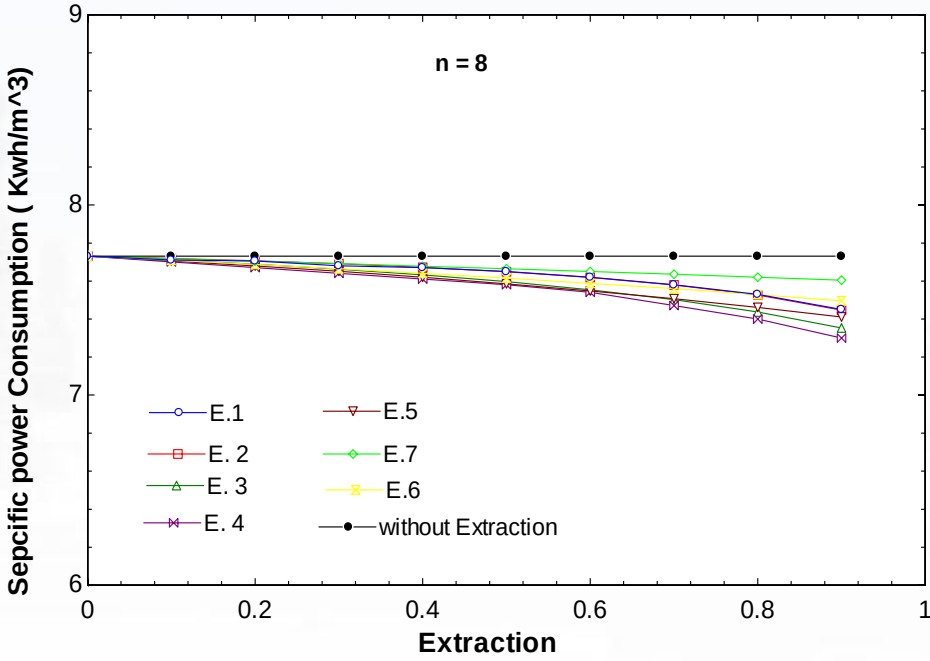

The First Mechanical Compressor
Compressed Vapor
C1
The second Mechanical Compressor
C2
Feed seawater
Extraction
mf, Tcw
(1)
(2)
(3)
(n)
Flashing Box
Distillate md
Brine mb
Feed
mf , Tcw

Models

- Mass Balance and Energy balance equations for all components.
- Model validation (base case) with maximum deviation of 0.22%
- Performance is evaluated through
  - Specific power consumption (Gain)
  - Specific heat transfer area (penalty)

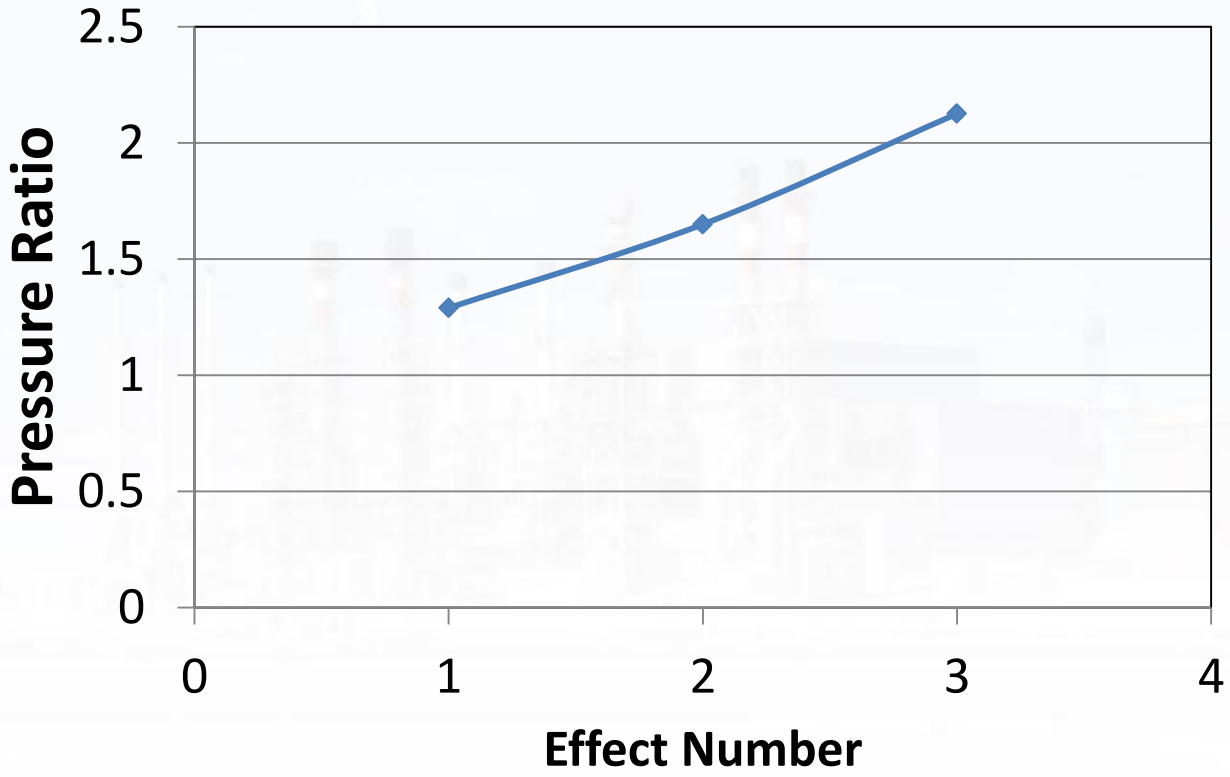
Results





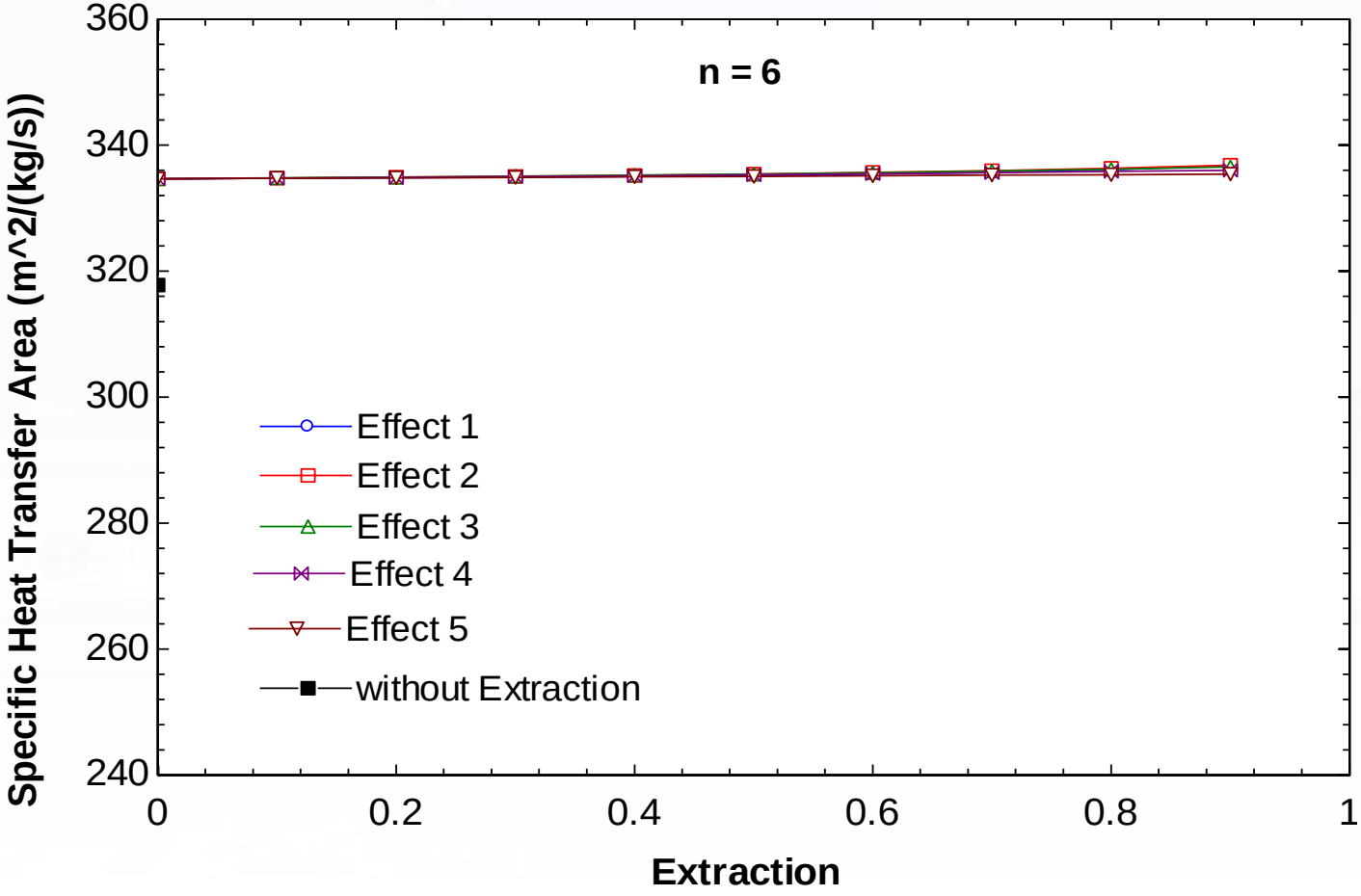
Change in the consumed power for the parallel feed (MED-MVC) with Extraction for n = 6,8 effects.

Results



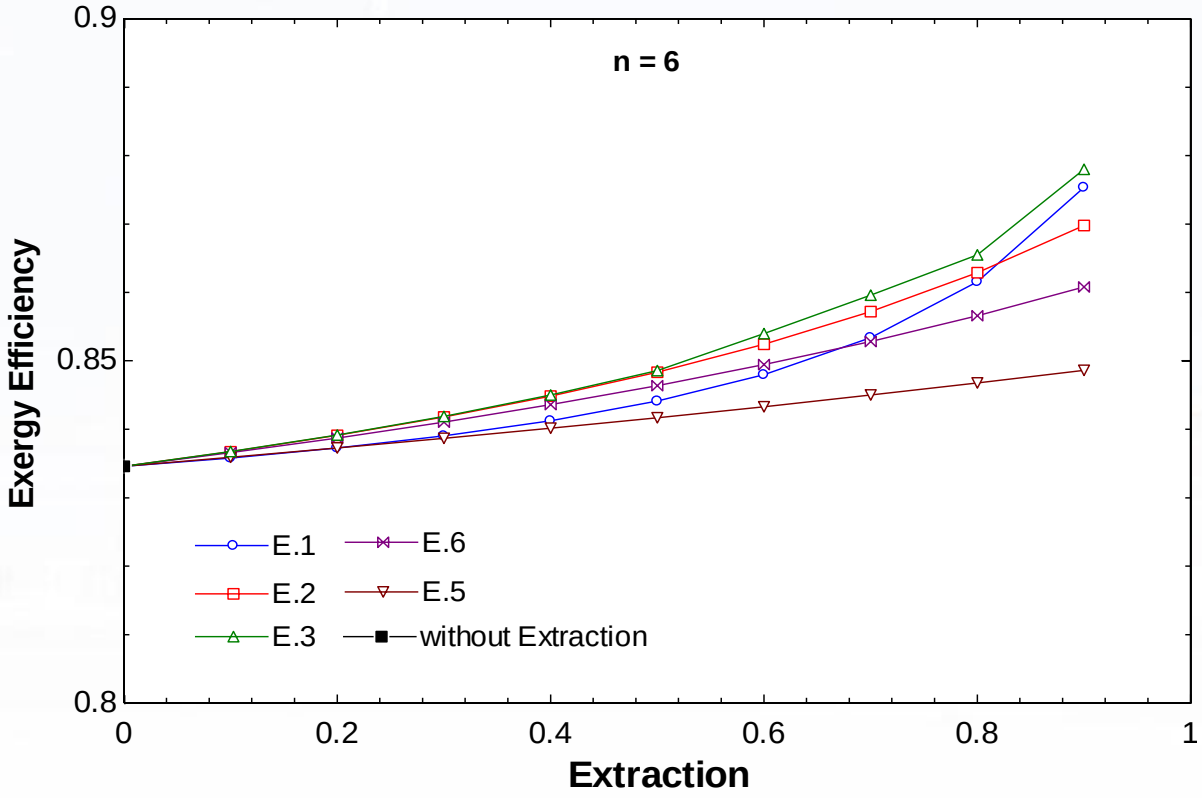
Change of the pressure ratio for secondary compressor for n = 4 effects

Results



Specific heat transfer area of the parallel feed MED-MVC with Extraction for n = 6 Effects.

Results



Exergy efficiency change of the parallel feed MED-MVC with Extraction for n = 6 Effects.

Conclusion

- Adding a secondary compressor improves Performance of MED-MVC-PF desalination system.
- Decrease in the vapor specific volume at higher operating temperature → reduction in the specific power for vapor compression.
- Extracting formed vapor from the middle effect (n/2) results in a best for the system performance.

Conclusion

- The Extraction rate has insignificant effect on the specific heat transfer area.
- Exergy efficiency increases with the extraction rate to increased flow to the secondary compressor.

Thank you