Water Desalination Through MED-TVC

IMPROVEMENT OF MULTI-EFFECT DESALINATION SYSTEMS: LOCATION OF VAPOR COMPRESSOR

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Outlines

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2. Desalination Processes
3. Previous Work
4. Objectives
5. Forward Feed Model
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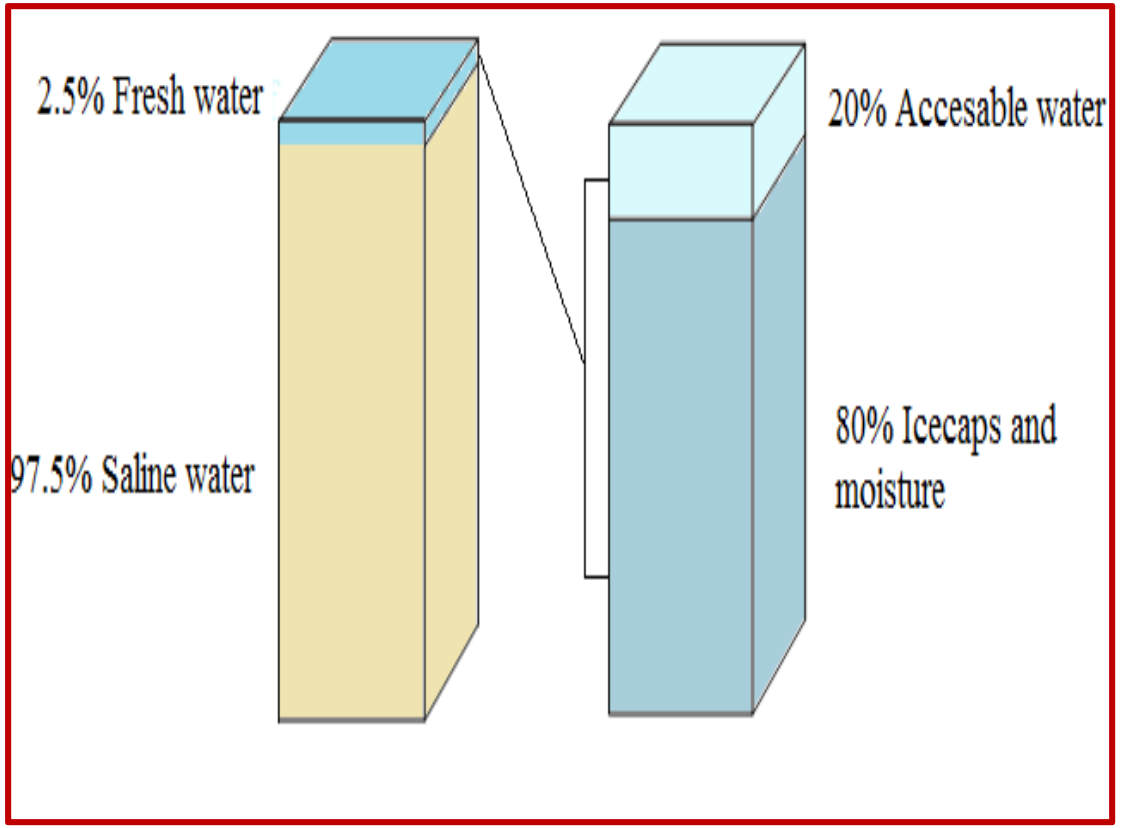
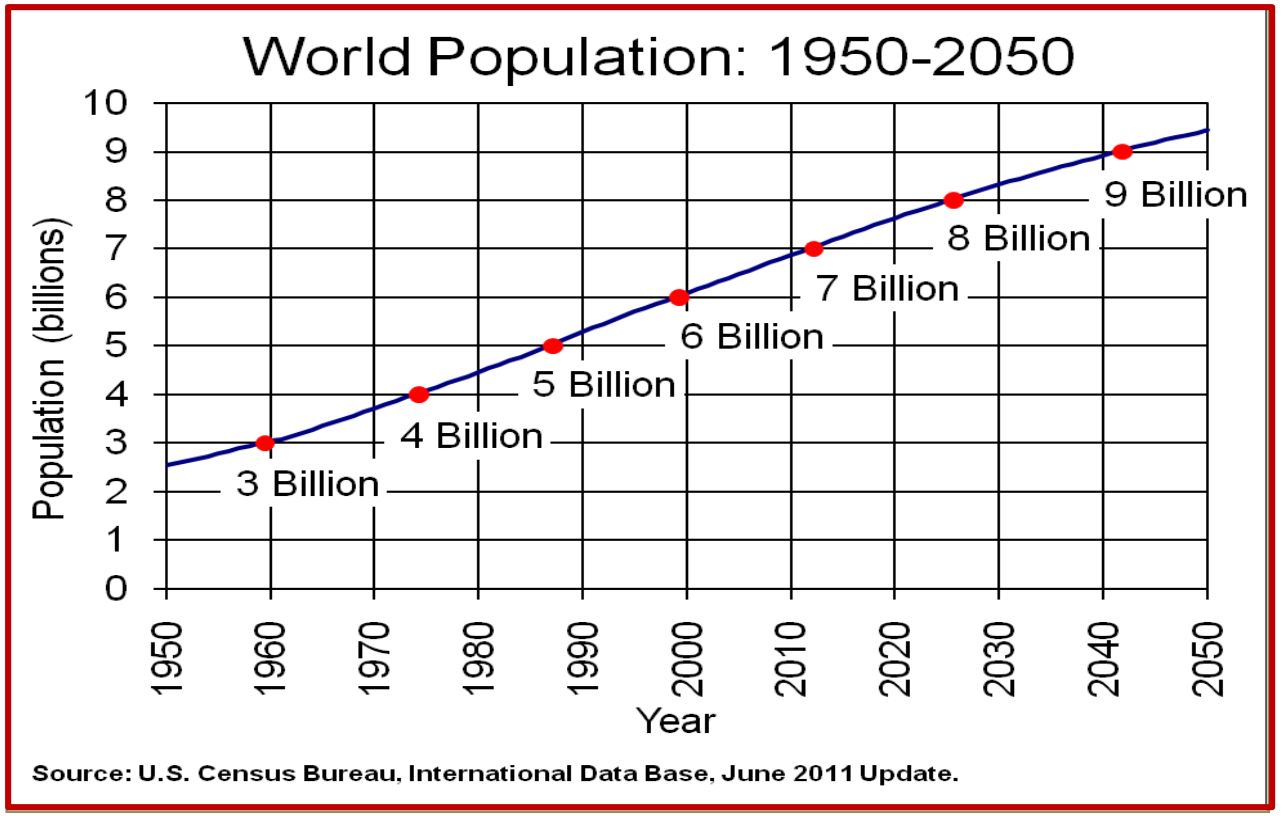
NEED FOR WATER FOR WATER DESALINATION

- 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



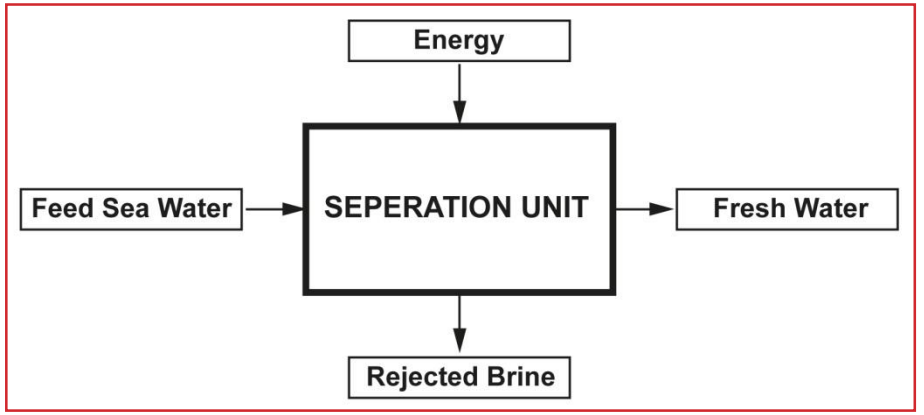
NEED FOR WATER FOR WATER DESALINATION

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



http://www.kivu.com/

Definition of desalination processes



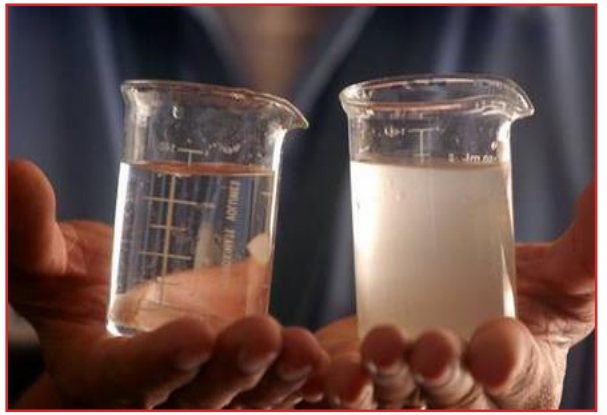
- Desalination process is a process of separation of fresh water from saline water
- Desalination process based on thermal or membrane separation .

Thermal Separation Include

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

The membrane separation include

- Reverse osmosis (RO)



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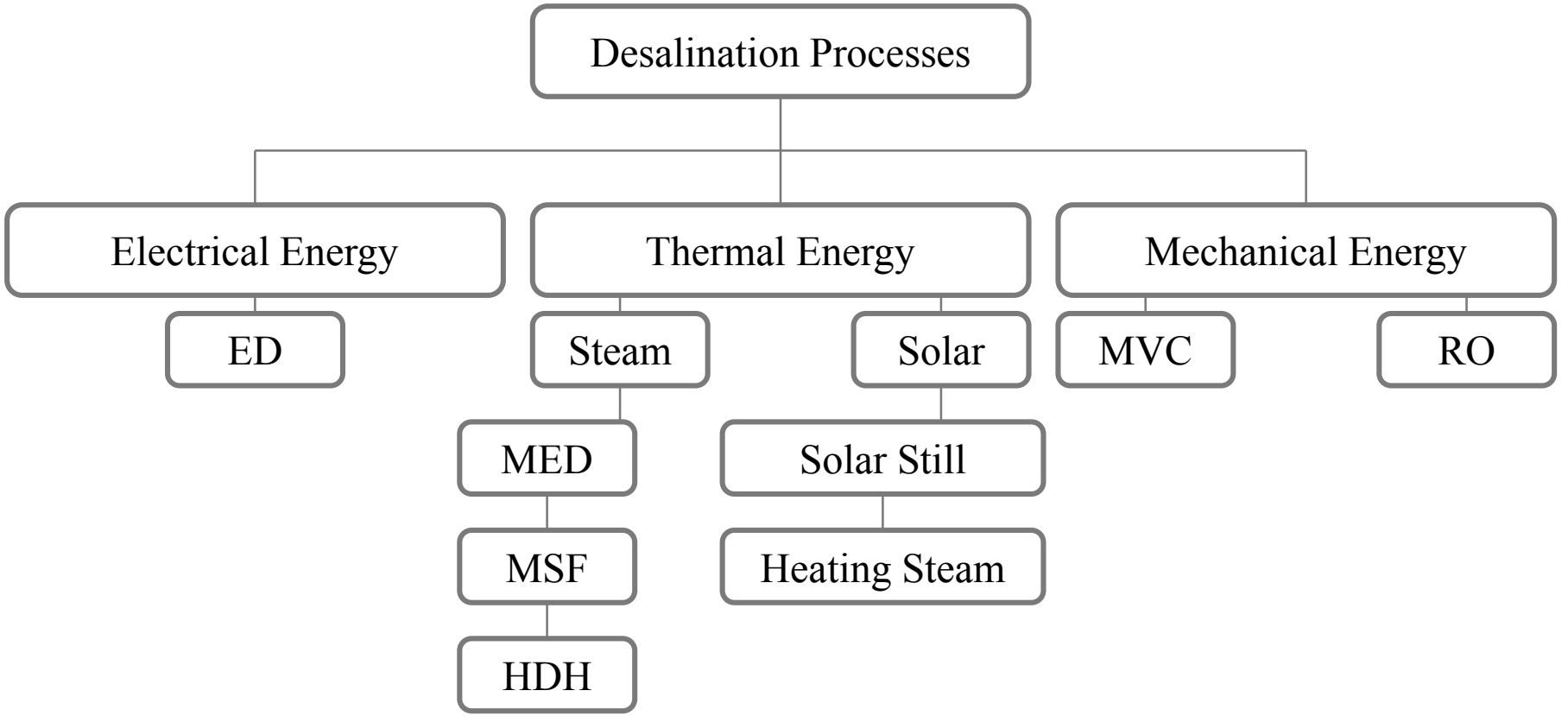
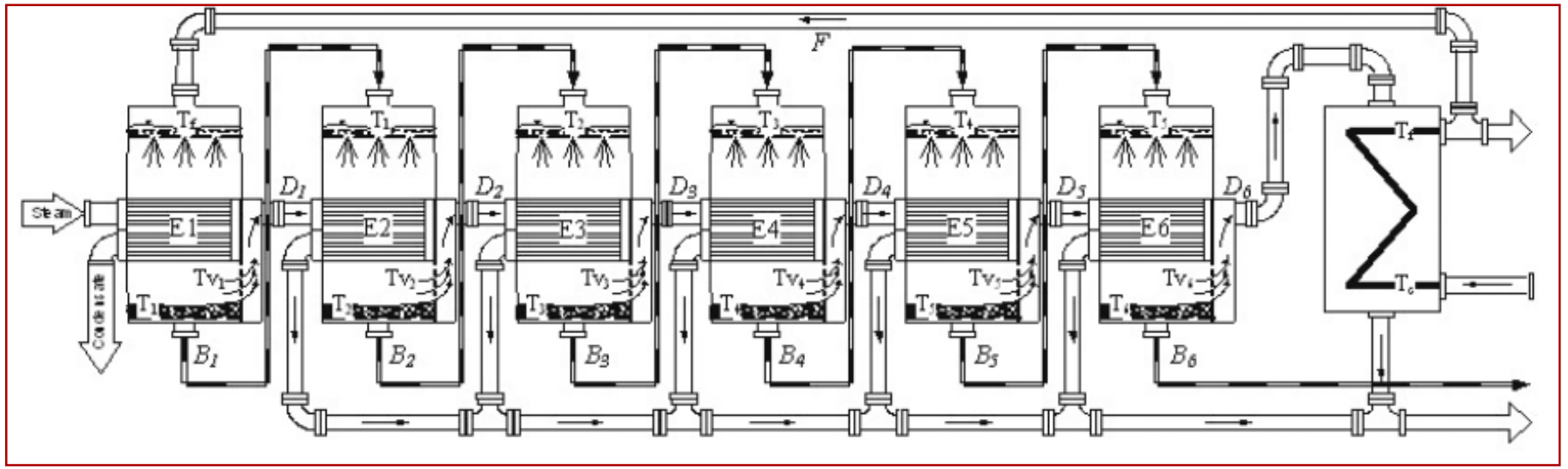

Desalination Processes
Electrical Energy
Thermal Energy
Mechanical Energy
ED
Steam
Solar
MVC
RO
MED
Solar Still
MSF
Heating Steam
HDH

Multi effect evaporation system Developments

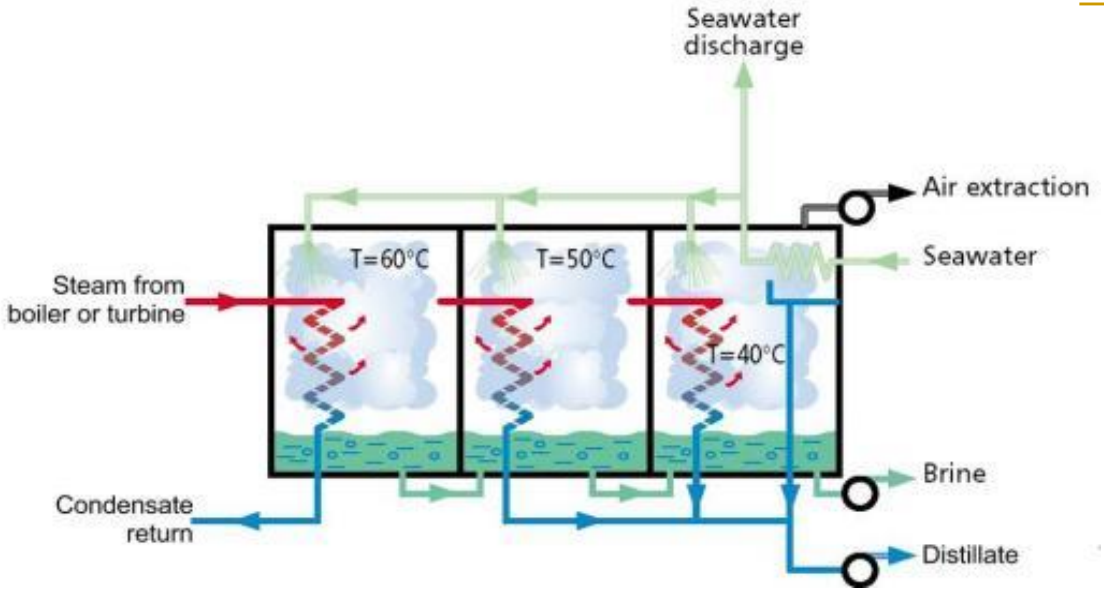


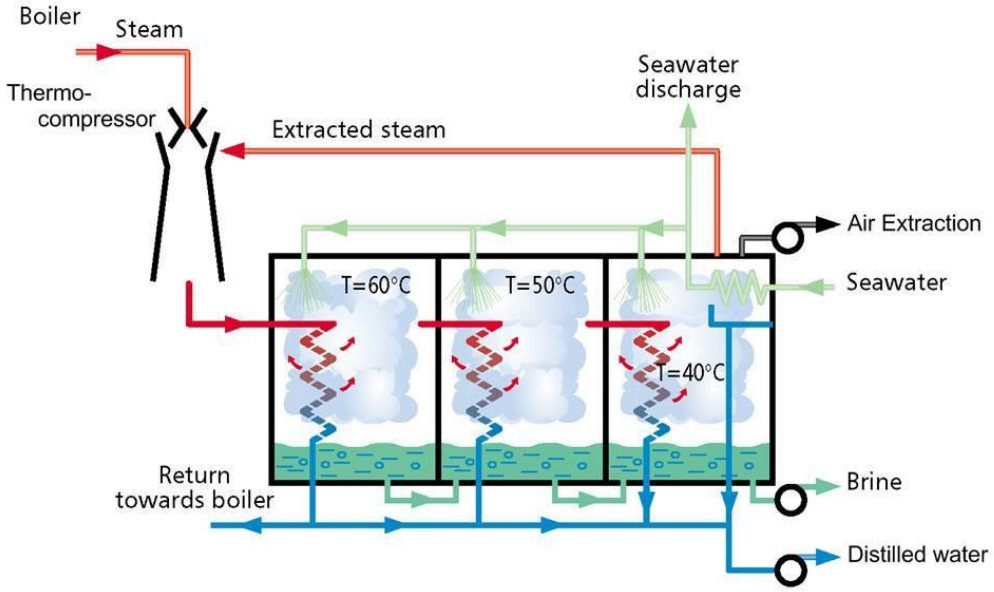
Darwish* and Abdulrahim Feed water arrangement in multi effect desalination systems

- 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

Multi effect evaporation system Developments

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





- 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
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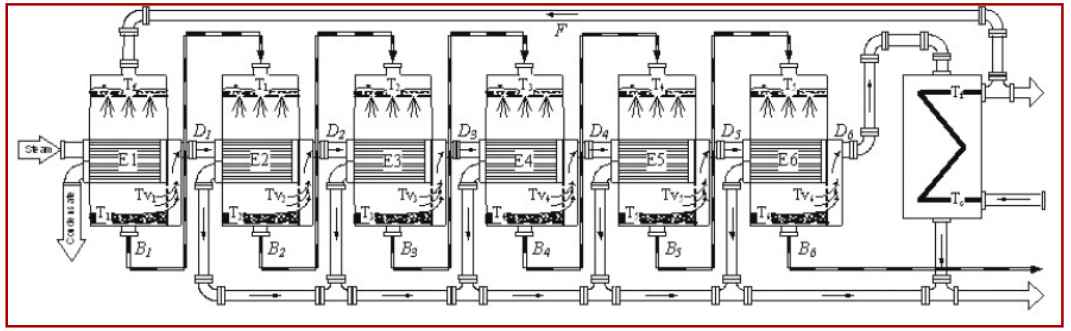
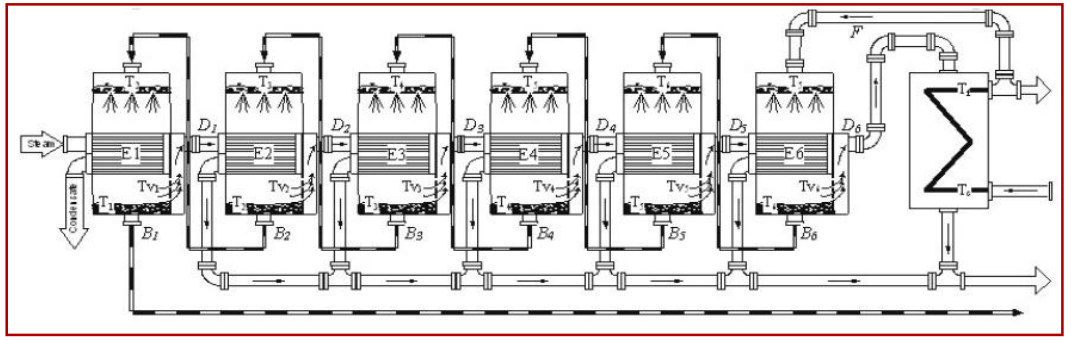
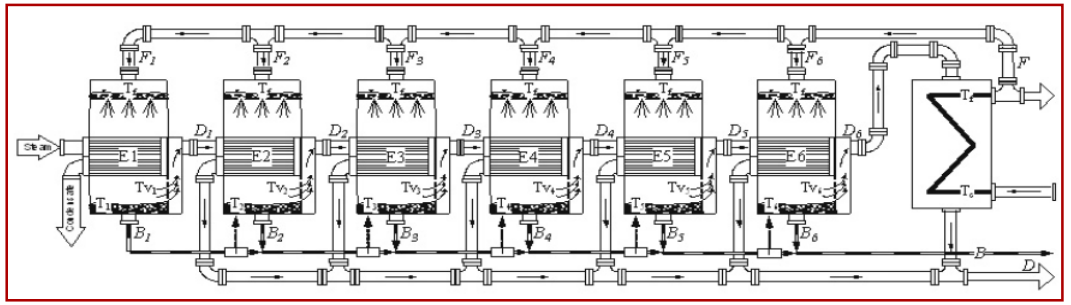
Schemes of supplying feed water to the evaporators

- Forward feed MED distillation system
- Backward feed MED distillation system
- Parallel feed MED distillation system







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

Authors	Year	Remarks
El-Dessouky et al.	1998	▪ Introduced ***mathematical model*** describing the MED system ▪ They concluded that the ***PR*** of the plant is nearly ***independent*** of the ***TBT***
El-Dessouky et al.	2000	▪ Running of both systems parallel/cross flow and parallel flow systems is preferential at ***higher temperatures*** as a result of the extreme ***reduction*** in the ***specific heat transfer area***
Ali and El-Figi	2003	▪ Studied the performance of MED-FF system, they pointed that the ***PR*** is notably ***dependent*** on the ***number of effects*** rather than the ***TBT***
Ophir and Lokiec	2005	▪ Reported that the MED is ***better*** thermodynamically and it is known as lower energy consumption ***compared*** to MSF system ▪ Very low specific energy costs for water desalination .

Authors	Year	Remarks
Darwish et al.	2006	▪ Normal MED system has the advantage of exploiting ***a low-temperature heat source*** when it works at low TBT ▪ The heat transfer areas ***increase*** considerably due to ***decreases*** of ΔT to less than 2˚ C ▪The Multi Effect Boiling system consumes about ***half*** of the Multi Stage Flash system pumping power.
Darwish and Abdulrahim	2008	▪ Developed MED model and analyzed different arrangements ▪ In all arrangements, increasing the number of effects increases the gain ratio, and the used specific heat transfer area.
Mistry et al.	2013	▪ Illustrated that the advantage of Cogeneration systems is being able to produce both water and power at ***lower costs*** .

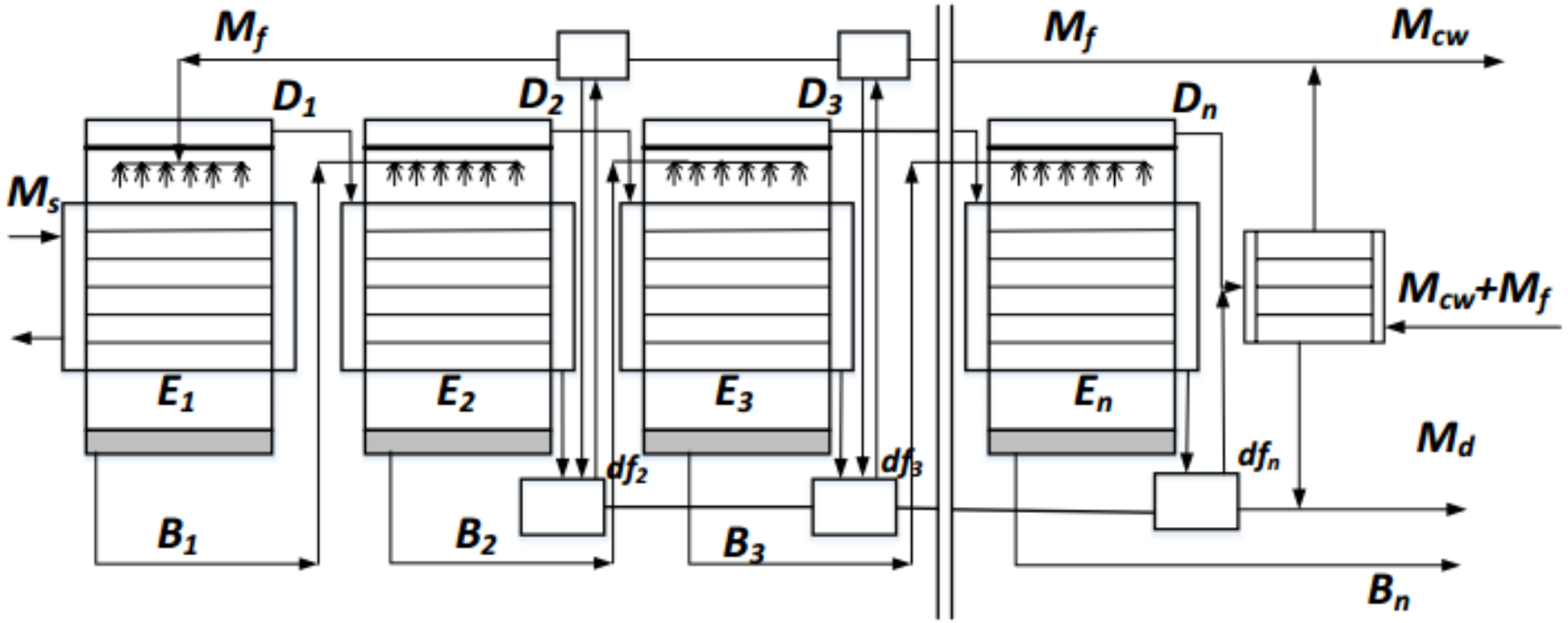
Authors	Year	Remarks
HAMED et al.	1996	MED-MVC and MED-TVC for 4 effects They reported that the MED-TVC system is more efficient than MED-MVC system.
El- Dessouky et al.	2000	MED-MVC (P & PC). The specific power consumption for MED-MVC parallel cross is lower than MED-MVC parallel feed.
Bahar et al.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

Authors	Year	Remarks
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.

Objectives

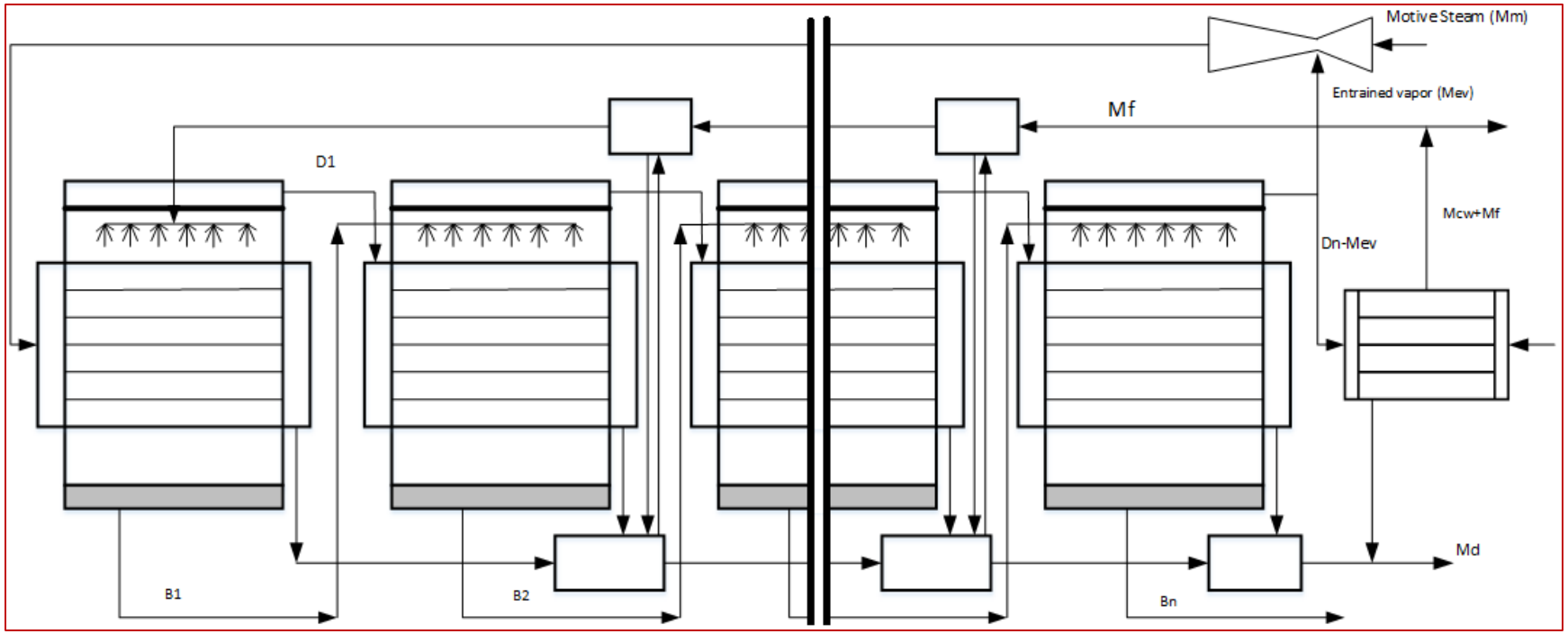
- To develop mathematical model for design and operation of multi effect desalination system based on energy and mass balances
- To assess several layouts of MED-TVC.
- Improving MED-MVC performance through the use of a secondary compressor that extracts vapor from one of the effects.
- To study the effect of changing the position of thermal vapor compression (TVC or MVC)

Forward Feed MED Model



$$PR = \frac{\dot{m}_d}{\dot{m}_s}$$

Forward Feed MED TVC Model

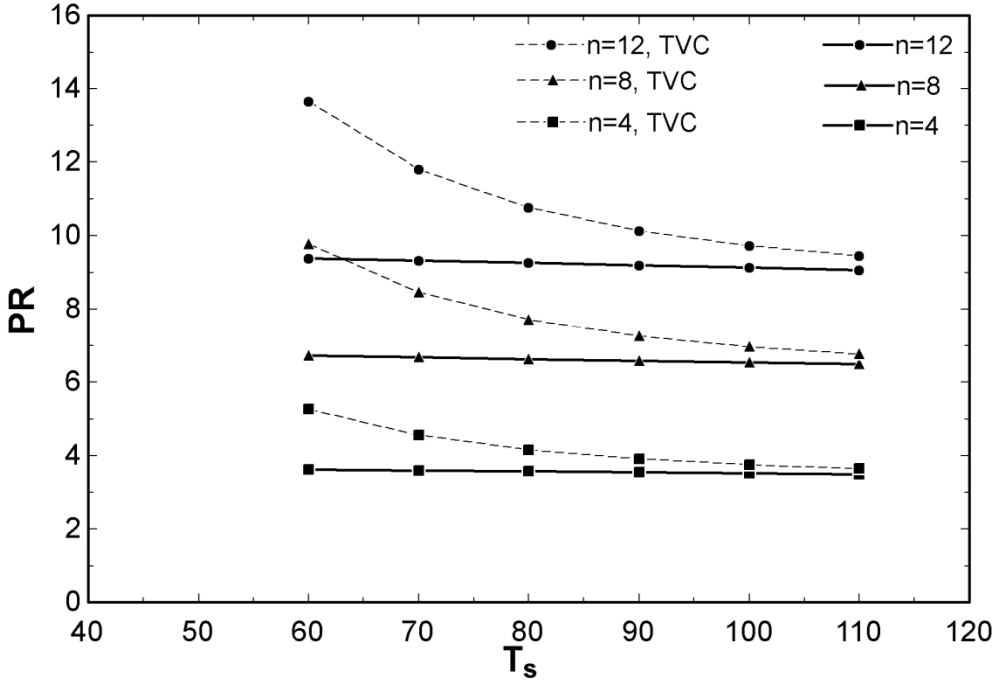


$$PR = \frac{\dot{m}_d}{\dot{m}_m}$$

Forward Feed MED TVC Model Results

At lower steam temperature, PR is high, as the steam temperature increases, PR decreases due to increasing of the motive steam flow rate to get higher compression ratio.

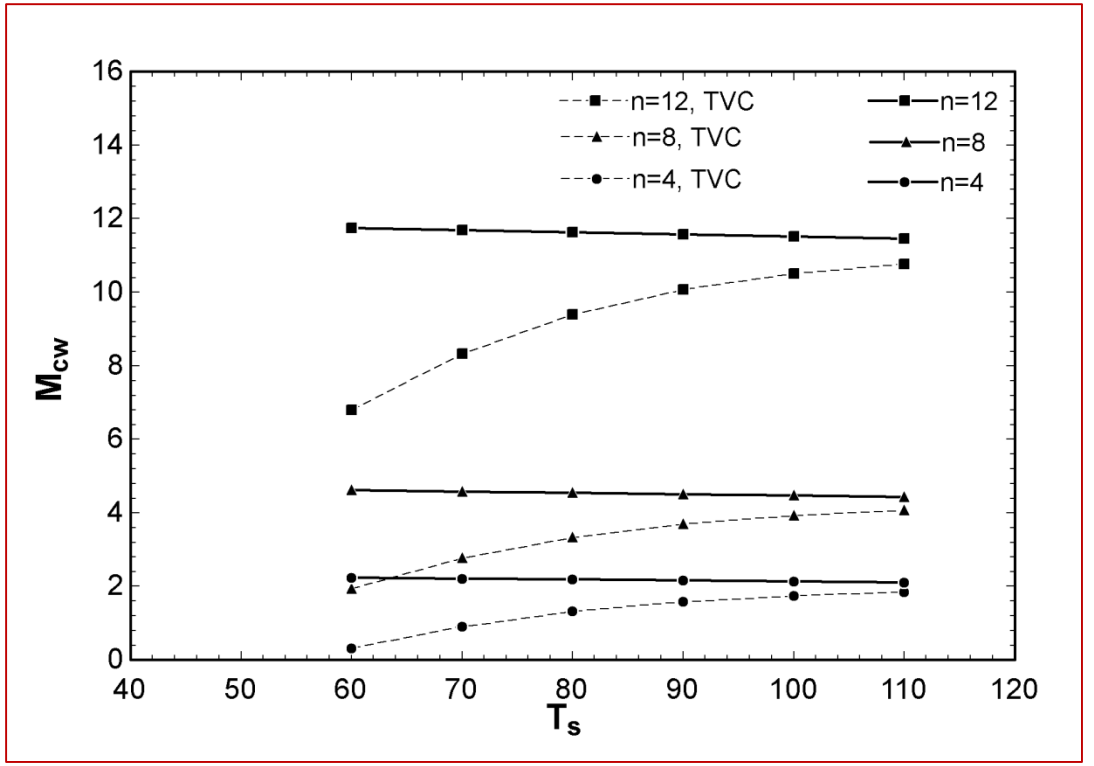
Increasing the number of effects increases PR due to better use of energy and vapors gained.



Forward Feed MED TVC Model Results

Increasing heating steam temperature increases the cooling water flow rate due to increase of the last effect thermal load as a result of increasing the compression ratio and the heat load of the first effect.

In addition, increasing the number of effects reduces the specific cooling water flow rate due to reducing the thermal heat load by increasing the number of effects.

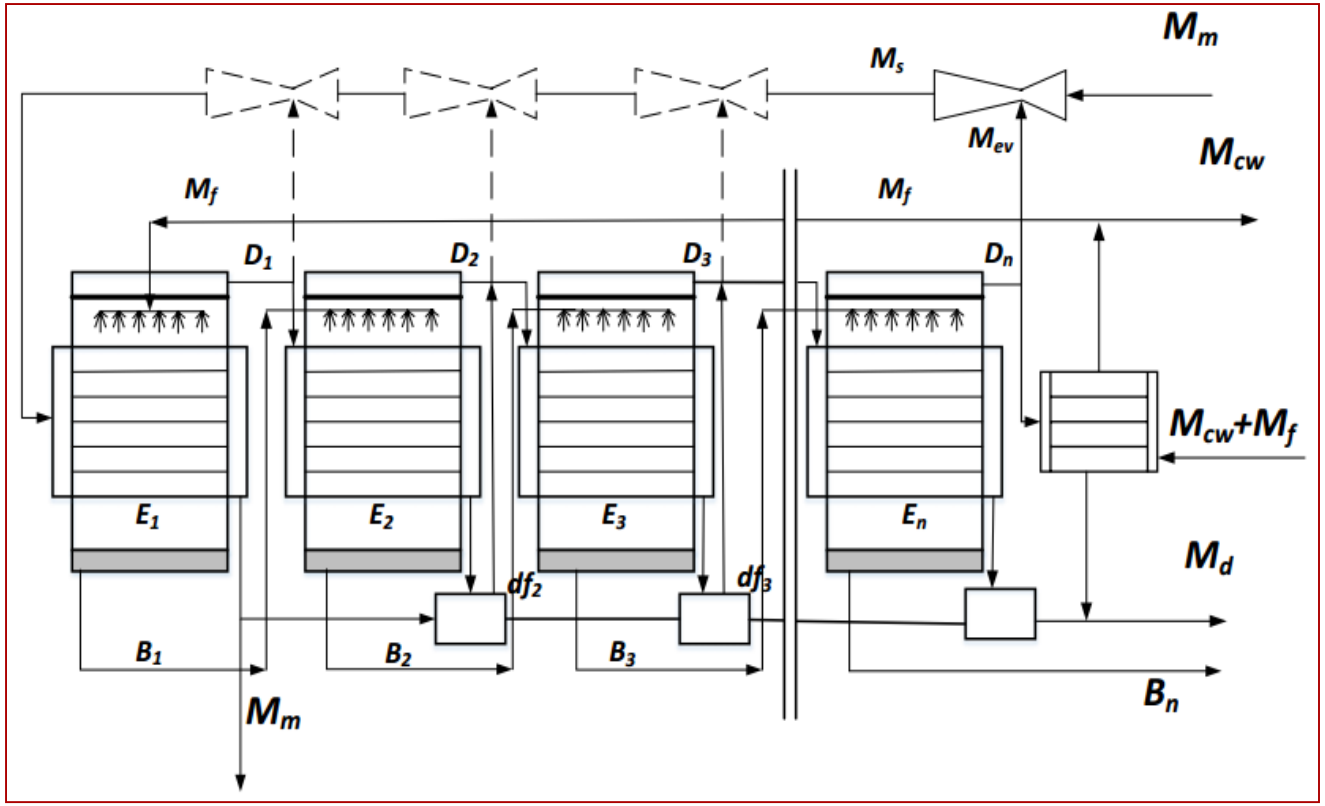


Forward Feed MED TVC different ejector positions Model

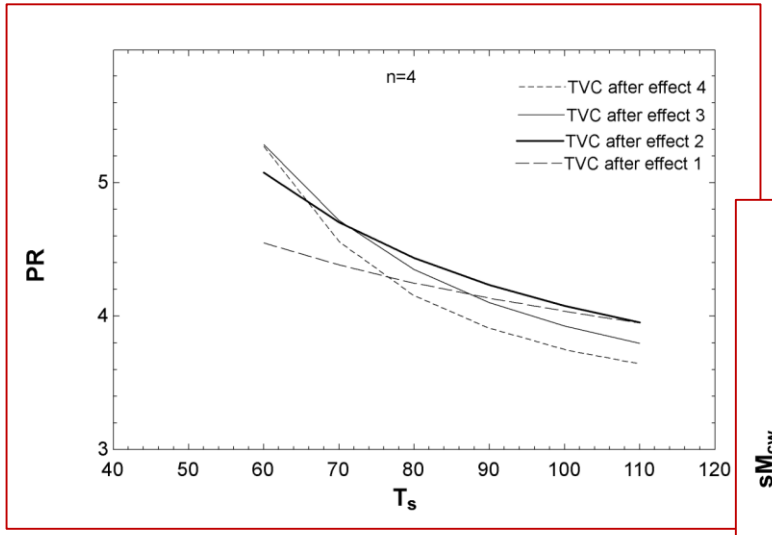
The heat load enters to the condenser

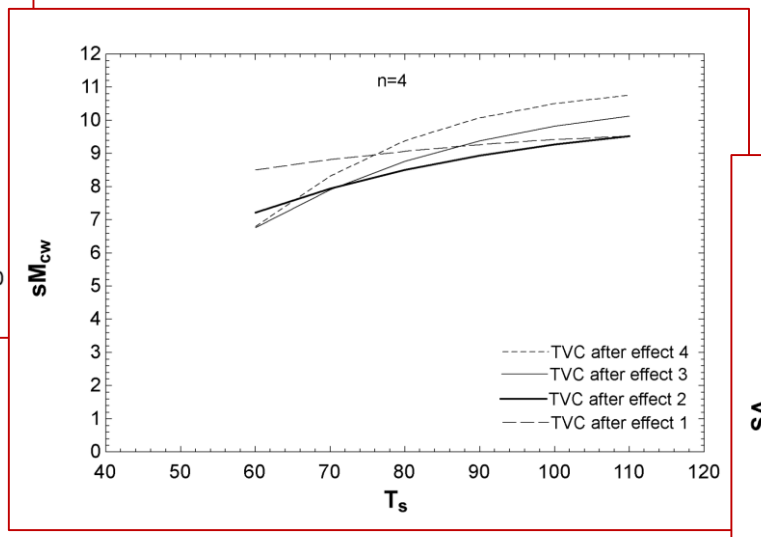
$$Q_c = (D_n - \dot{m}_{ev}) * Lv_n$$

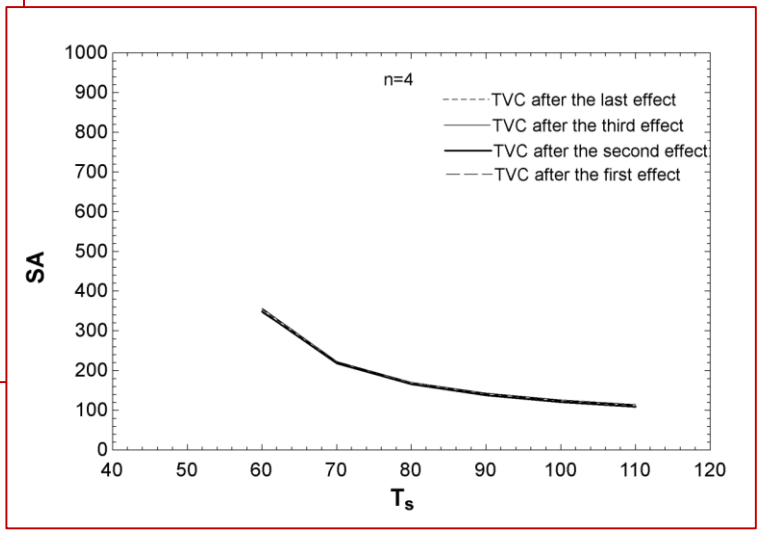
$$Q_c = (M_{cw} + M_f) * C_p * (T_f - T_{cw})$$



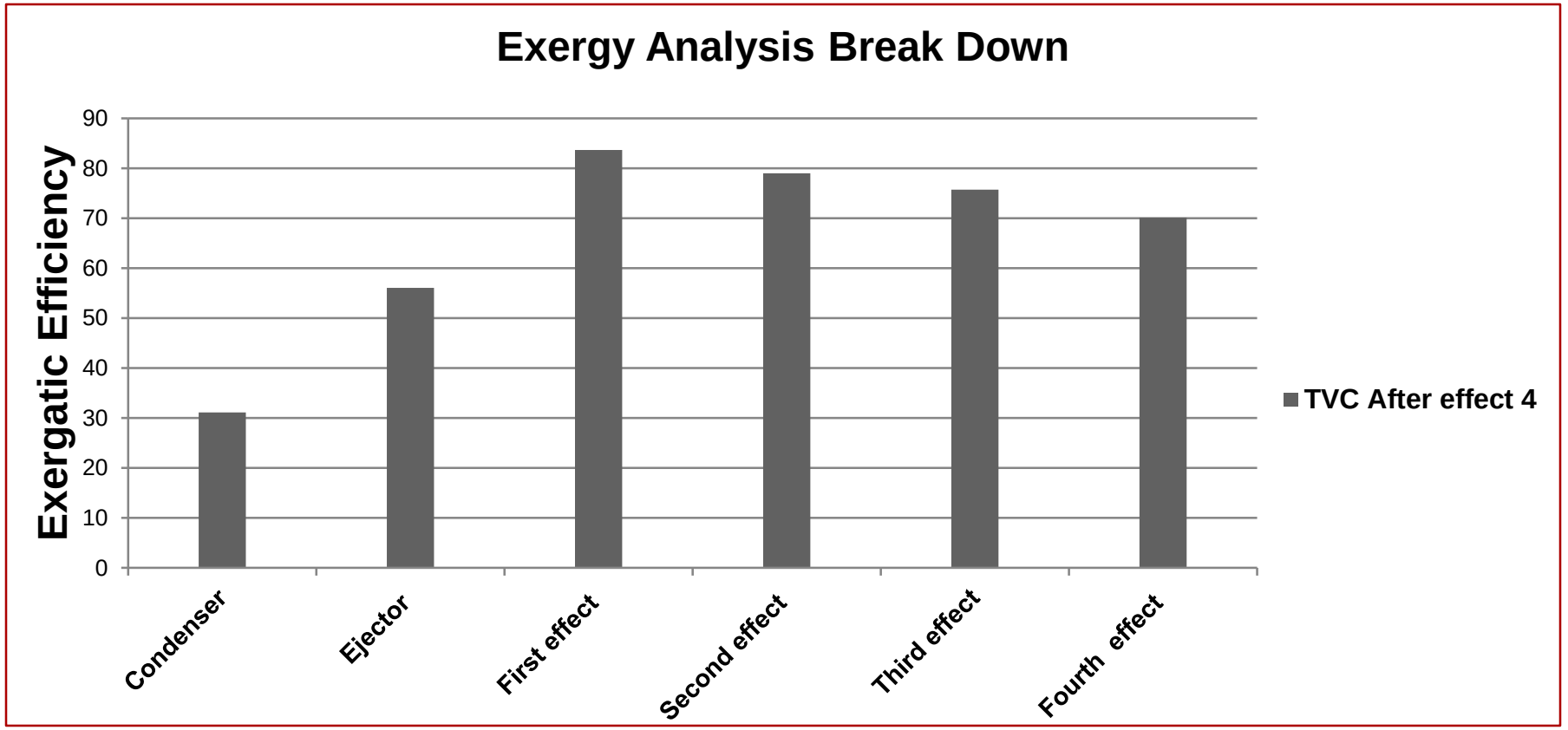
Forward Feed MED TVC different ejector positions Model Results



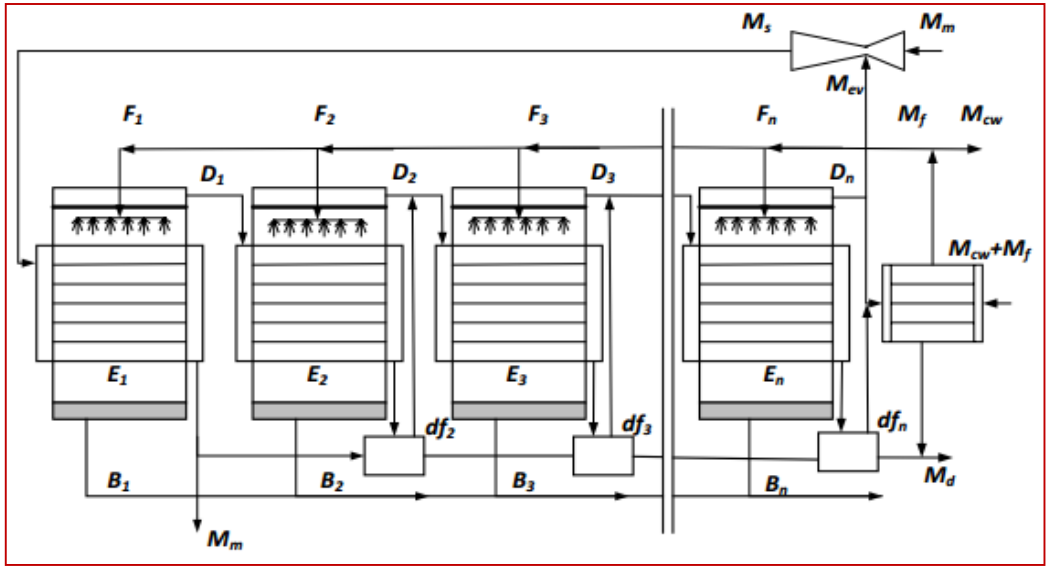


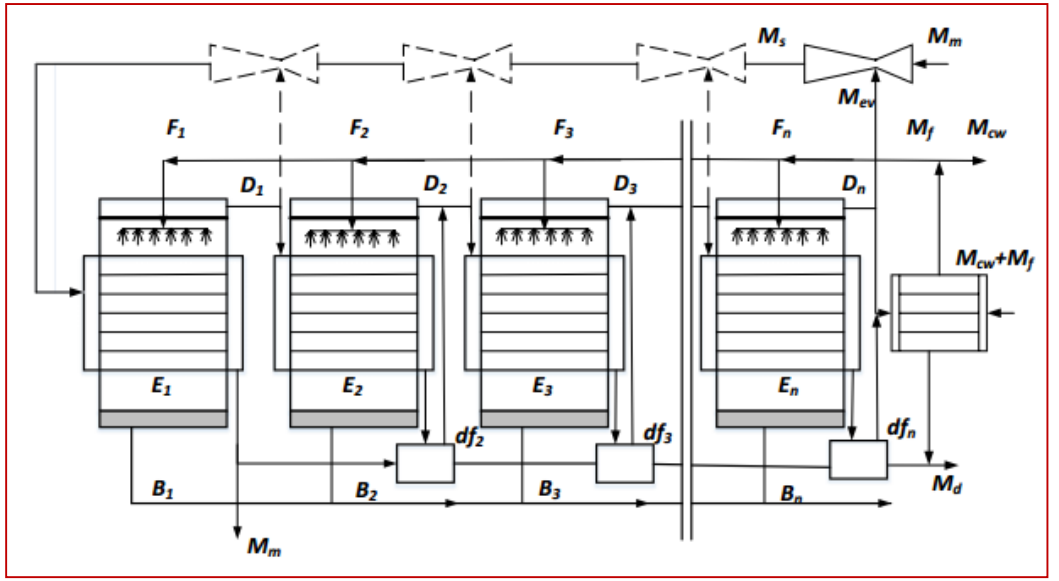


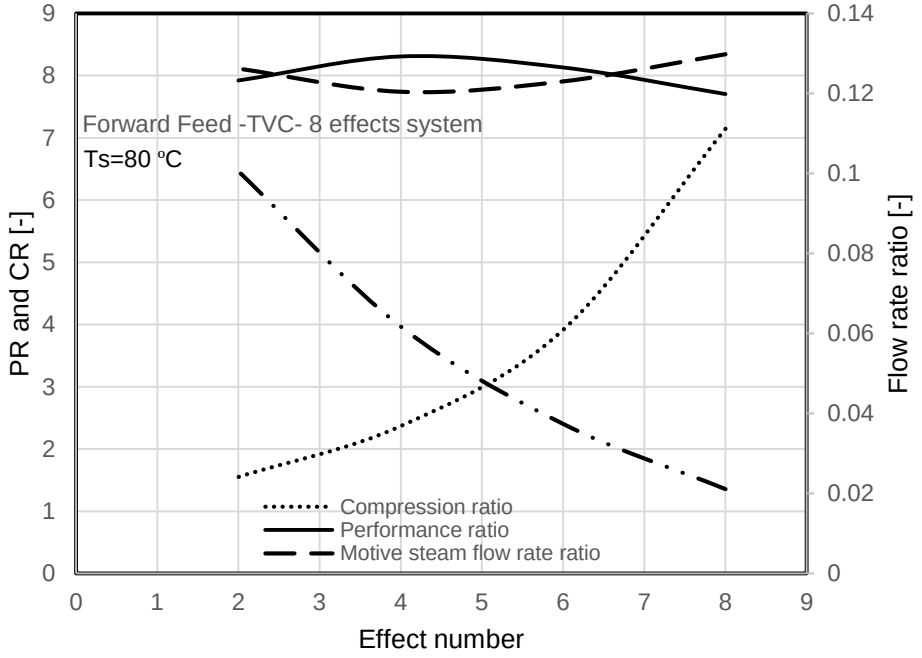
Forward Feed MED TVC Exergy Analysis Results



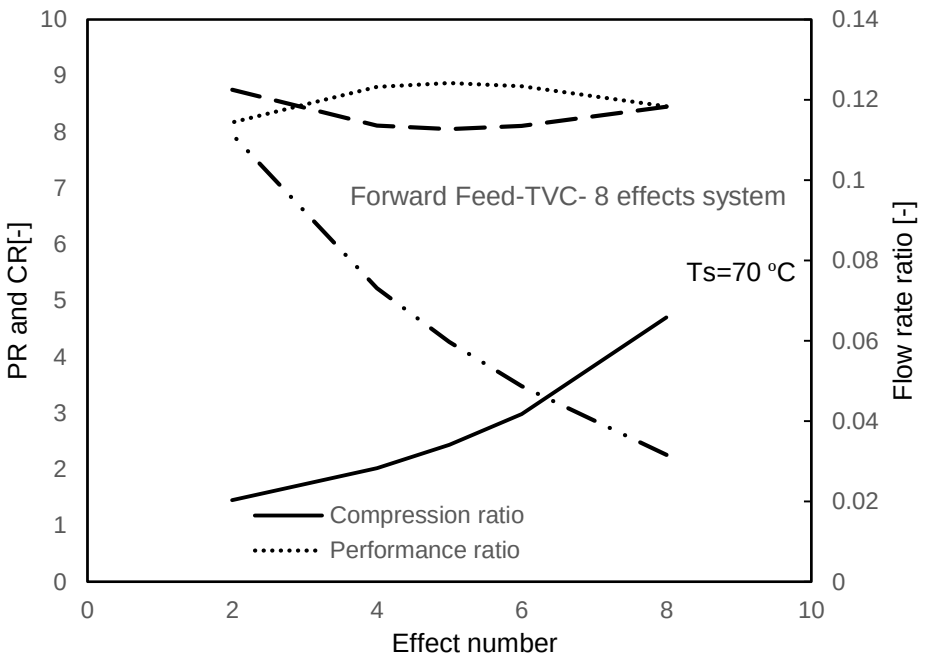
Parallel Feed MED TVC Model



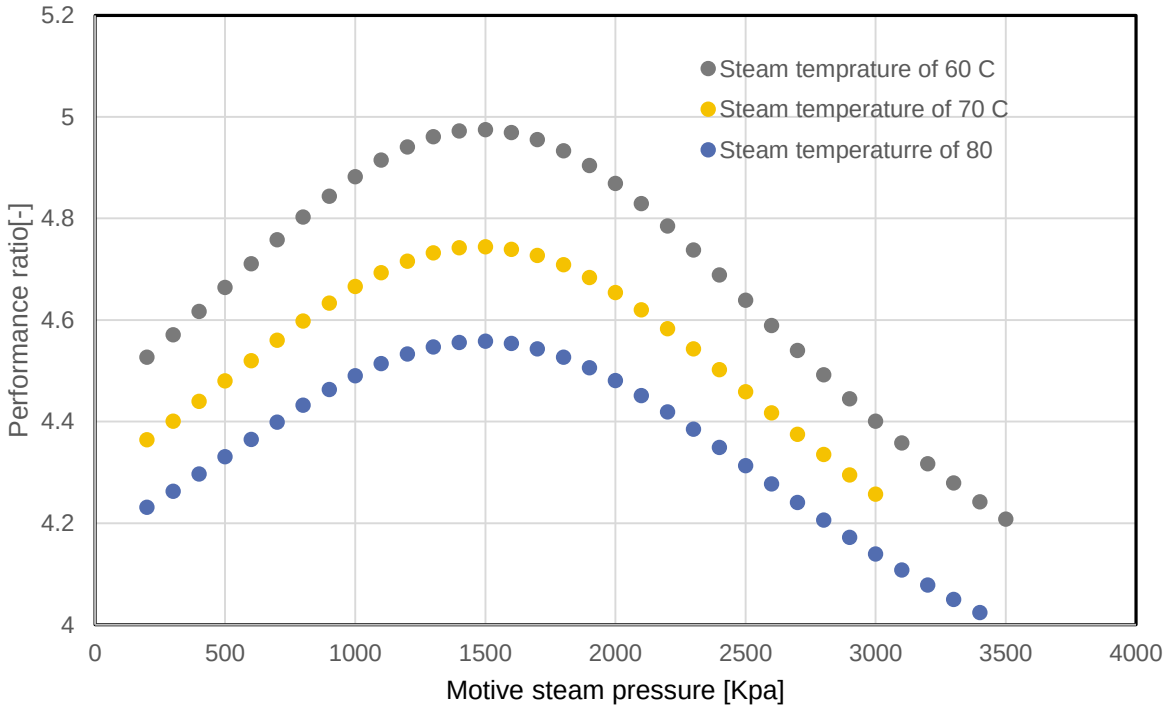




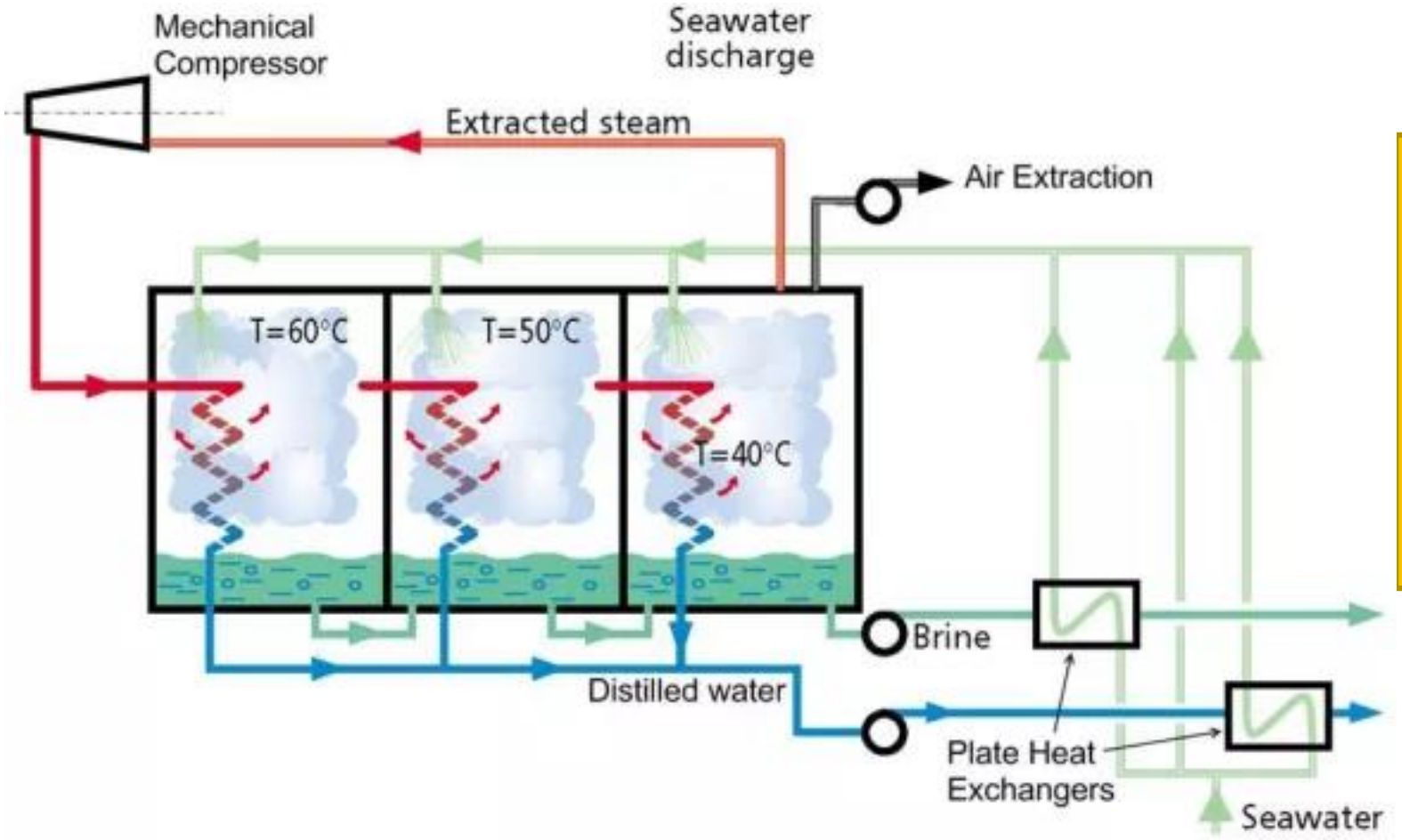
Effect of changing the location of TVC on the performance ratio at steam temperature of 80 °Cfor a MED-FF system, N = 8



Effect of changing the location of TVC on the performance ratio at steam temperature of 70 °C for a MED-FF system, N = 8



Effect of changing motive steam pressure on performance ratio

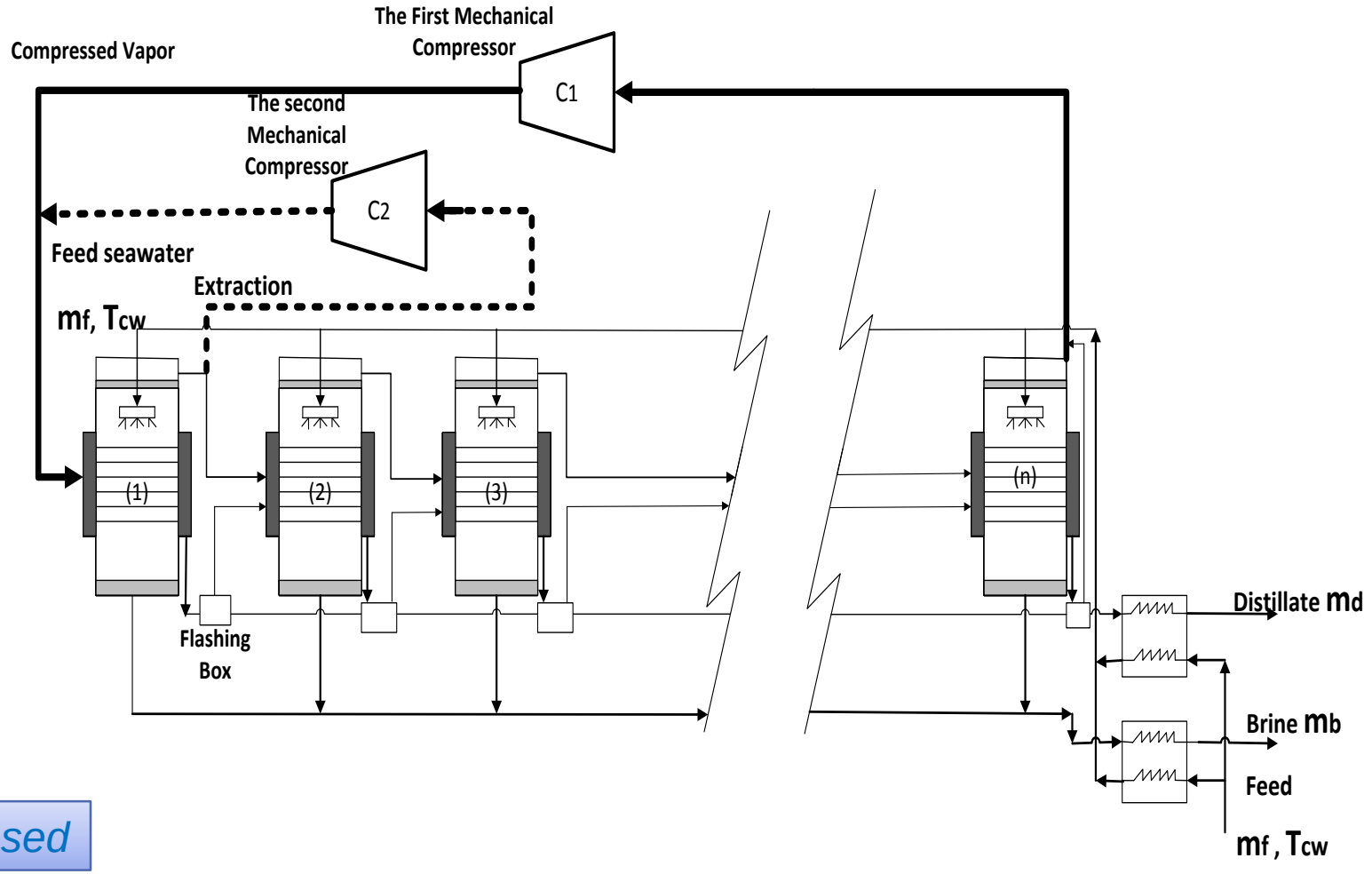


Features:

- Compact
- Independent of external heating source
- Remote areas, operated by Diesel engine, wind turbine….

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

PROPOSED



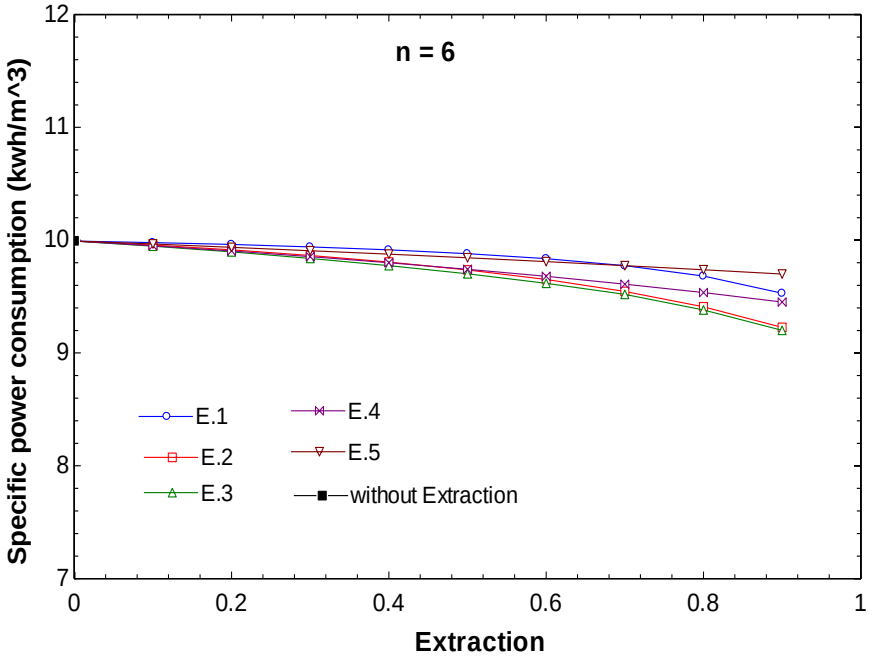
Patent Disclosed

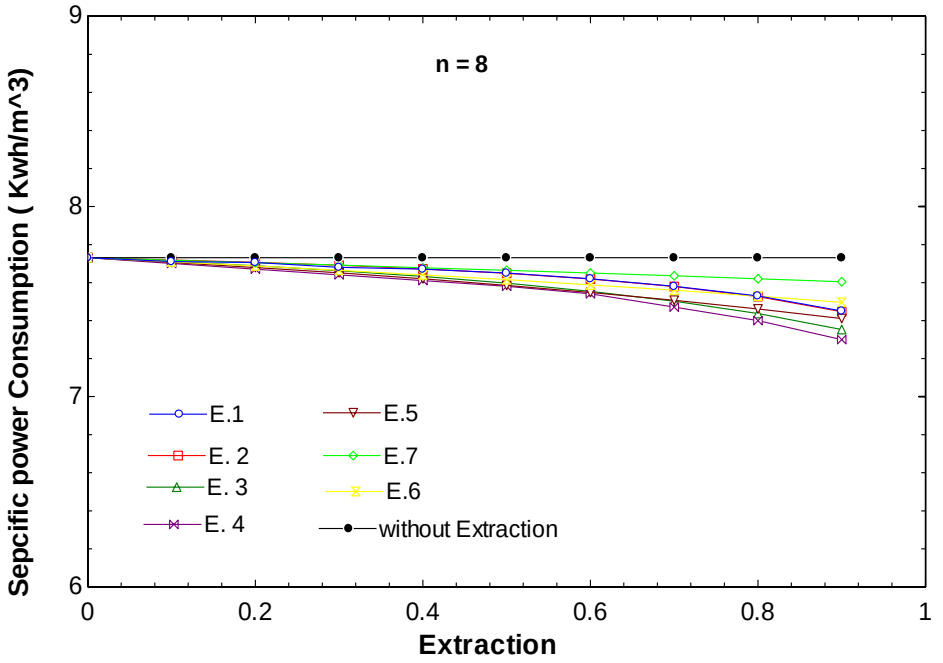
This addition improves the system performance through

- 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??

Patent Disclosed





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

- TVC increases PR of the system and reduces the specific cooling water flow rate.
- Changing the position of the ejector affects the Performance ratio and the specific cooling water flow rate
- However, the best performance occurs for wide range of heating steam temperature when the ejector is situated in the middle
- Increasing the number of effects increases the second law efficiency.

- Adding a secondary compressor improves Performance of MED-MVC-PF desalination system by about 10%.
- Decrease in the vapor specific volume at higher operating temperature → reduction in specific power for vapor compression.
- Extracting formed vapor from the middle effect (n/2) results in a best for the system performance.
- Insignificant effect of extraction rate on the specific heat transfer area.


THANK
YOU