MSF performance improvement by using thermo-vapor compression

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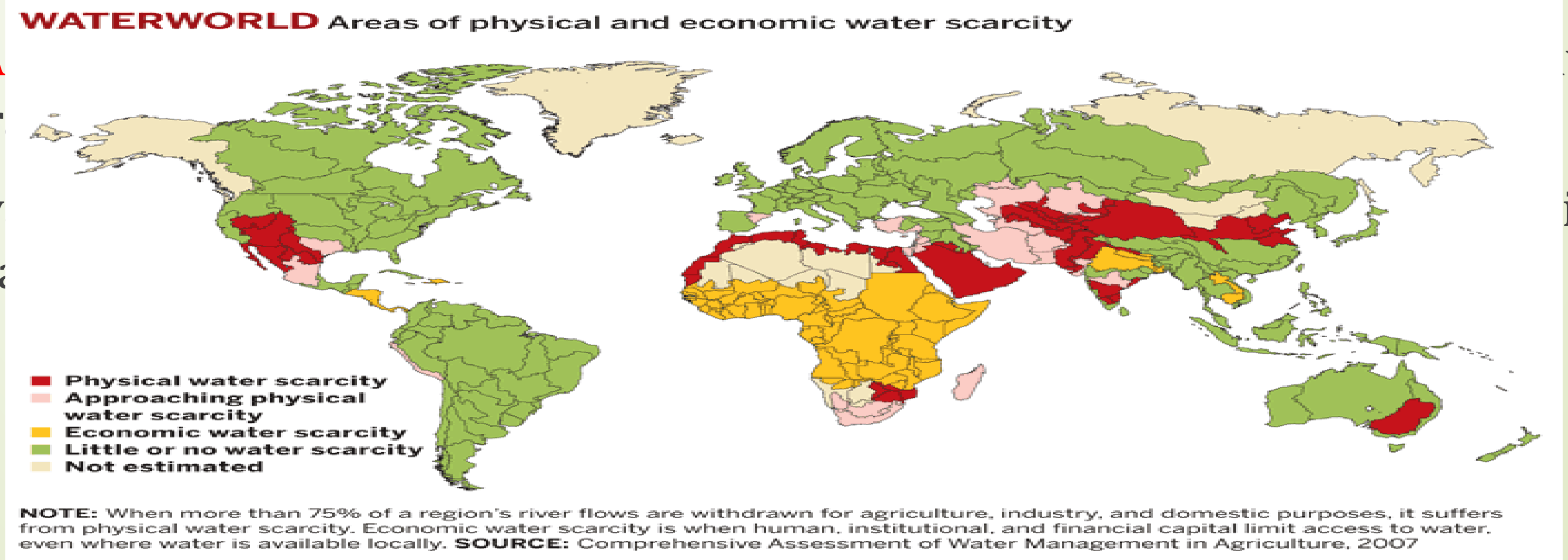
Presentation Outlines

- Introduction
- Objectives
- Model
- Results and Discussion
- Conclusions

Introduction

Concerns

- Water scarcity is …..
- More than 1.2 billion people lack access to clean drinking water.
- In 2020 the world populations would be 7.5 billion and this growth is more pronounced in water scarcity area.
- Predicted lower rainfall in future and increased temperatures caused by climate change are likely to magnify the problem.
- Saudi A … ving on aver …
- Daily w … ia, double the EU a …



Solution

- So our concern is …
- To survive, we need fresh water.
- Sustainable solutions are required like reclamation, reuse, awareness….etc.
- Obviously for more fresh water demand desalination is the best solution of water shortage .
- Multi stage flashing is a denominating desalination technology, locally.
- No indication is suggesting that it is going out of service anytime soon.
- We aim to reduce the power consumption of MSF desalination plants, and improve performance.

Desalination in Saudi Arabia

- Saudi Arabia has been recorded in 2019 as the world largest desalinated water producer by a daily production of 7.2 million m^3.
- Nearly 70 % of this production is from MSF (Multi Stage Flashing) plants where the rest of production is produced by RO (Reverse Osmosis) plants and with less contribution by MED (Multi effect distillation) plants .
- MSF Brine-Recirculation technology is still used efficiently in many desalination plants around the kingdom with approximately 96000 m^{3}/d

Desalination in Saudi Arabia

- However, the MSF performance ratio is still relatively low in comparison with MED due to high consumption of steam and the power required to operate the unit.
- The best MSF performance ratio is recorded at 9.5 where the specific power consumption is varying from 3-4 (kwh/m^3).
- MED, however, due to operation constrains like limitating TBT <66^oC, as well as the critical operation conditions of TVC like suction vapor pressure stability.
- Unlike MSF & MED, RO technology is a single source energy and can easily be constructed and operated but membrane life is critical such that nearly 20% of membrane is replaced every year.

Objectives

MSF problem statement

MSF system basically works in a cogeneration cycle with power plant as it is regarded as heat sink for the power cycle where the 1^{st} law of thermodynamic is applied as

Heat added by steam in BH=Heat rejected by cooling seawater heat rejection

MSF is working under vacuum condition with maximum top brine temperature around 120 C and bottom brine temperature around 36 C .

MSF Performance R

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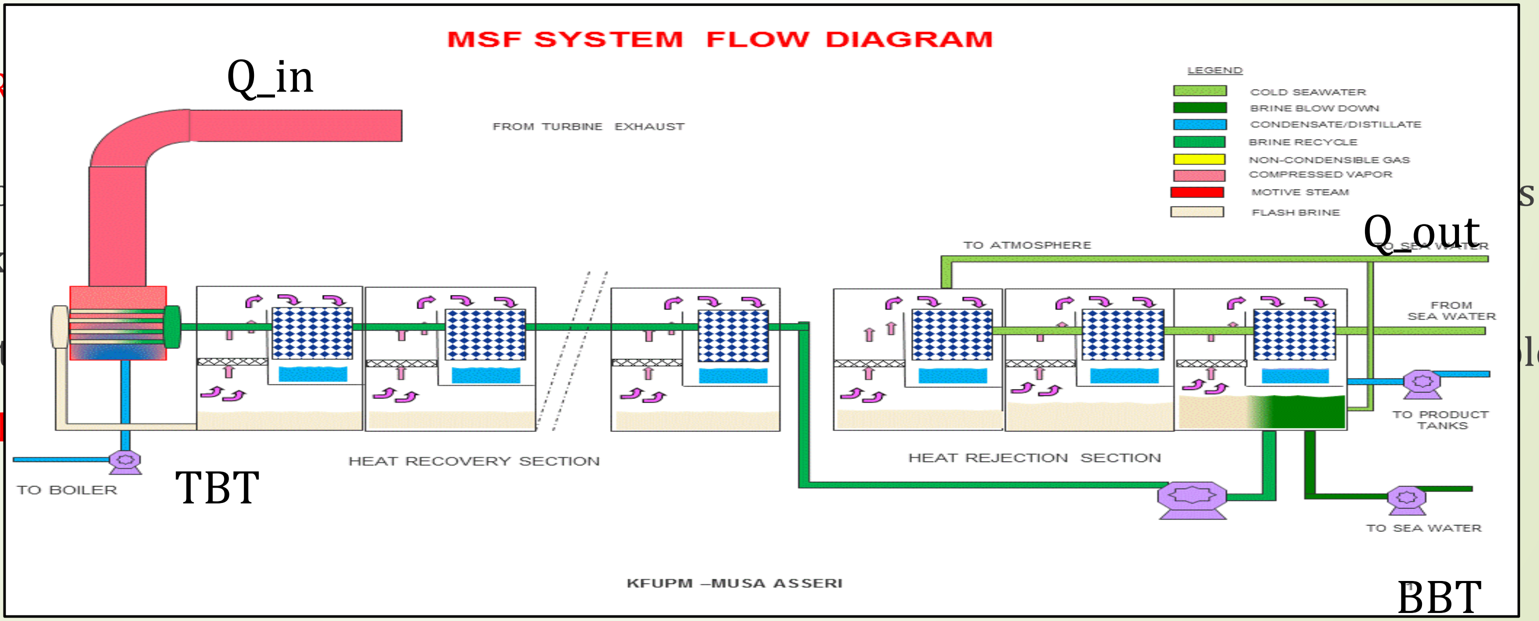
Therefore, MSF syst … lementing (thermo vapor comp

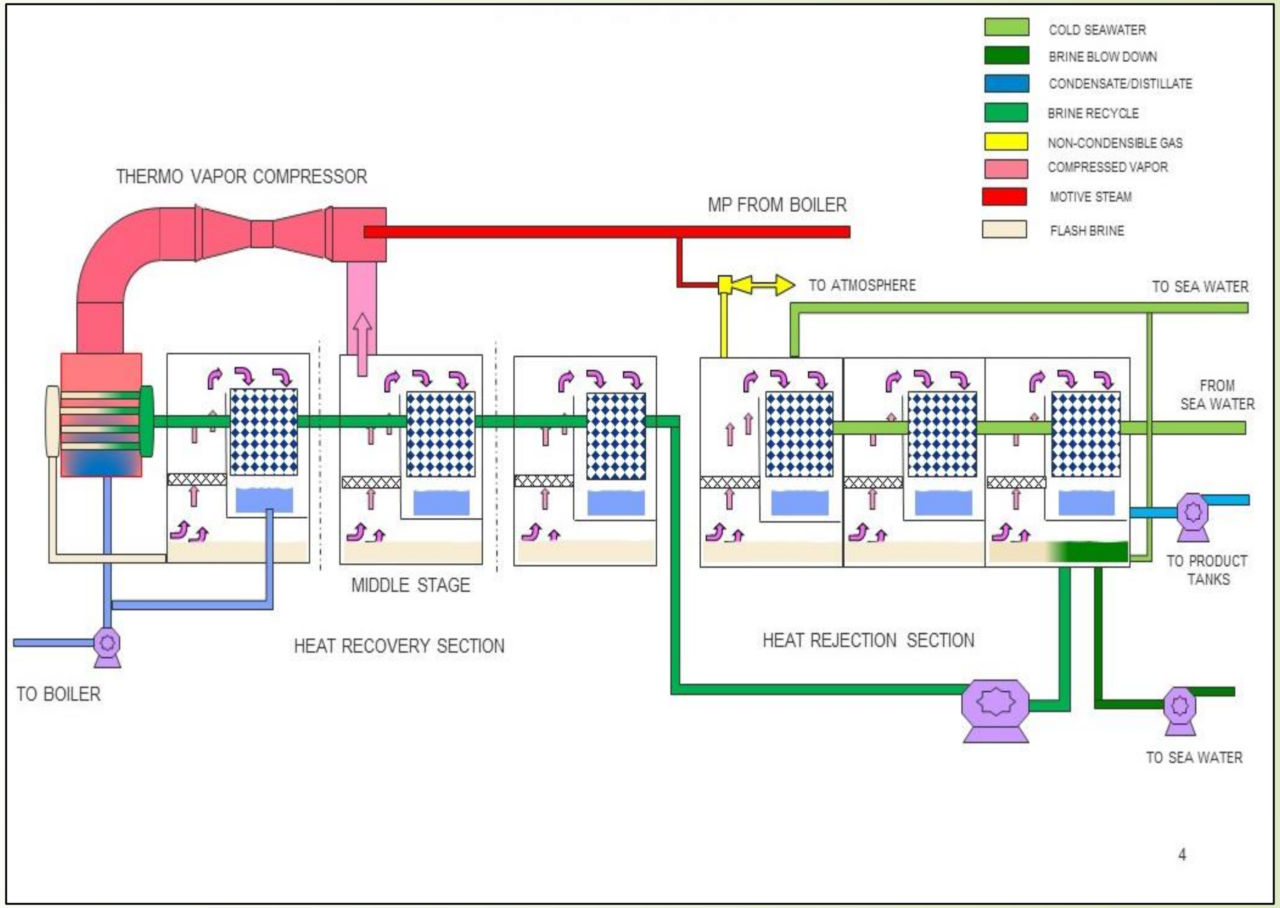


Schematic of the proposed model.

- Medium pressure supply line.
- Thermo vapor compression unit.
- MSF unit.

We would like to find and analyze:

- Performance of MSF systems
- Performance of MSF system combined with thermo vapor compression unit.
- Cogeneration impact.

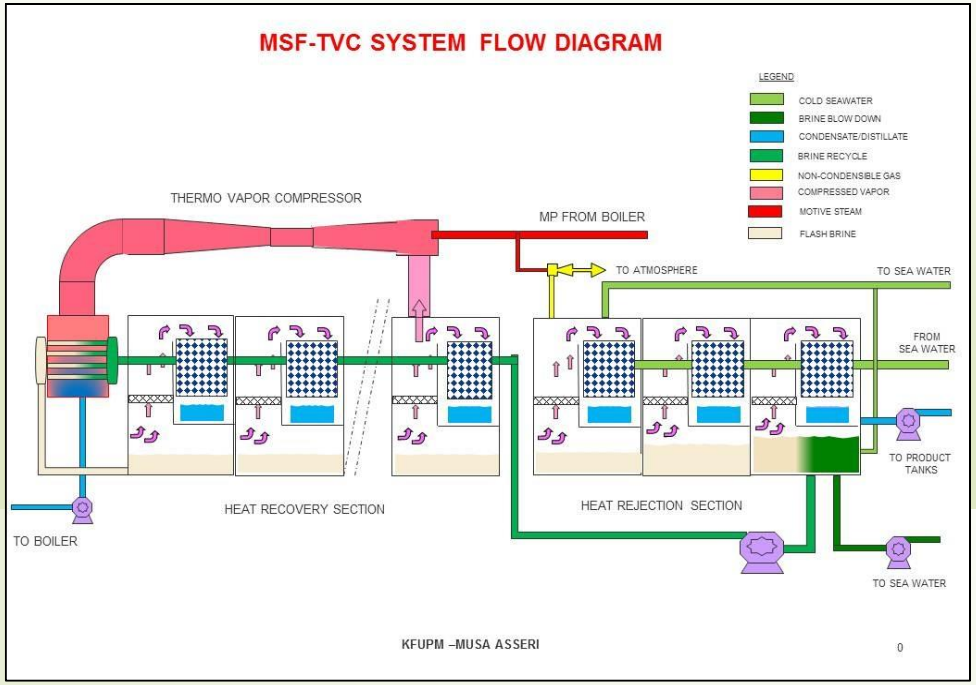


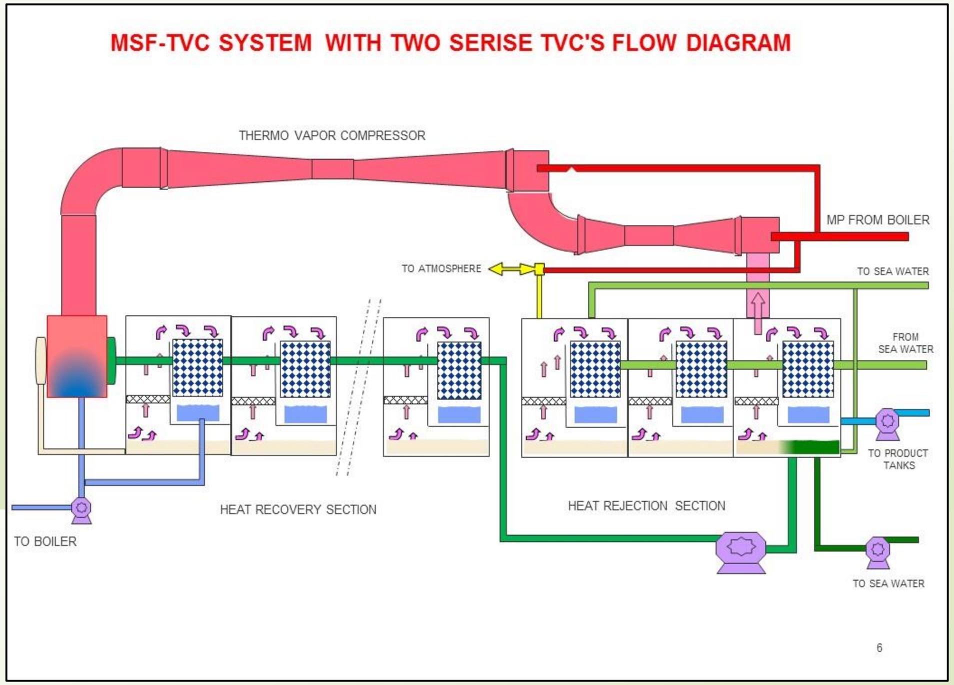
MSF-TVC proposed system

Model

MSF-TVC MODELING APPROACH

- We integrated two configurations for TVC; single or double TVCs connected in series .





MSF-TVC configurations diagram

MSF JUBAIL PLANT DESIGN /OPERATION DATA

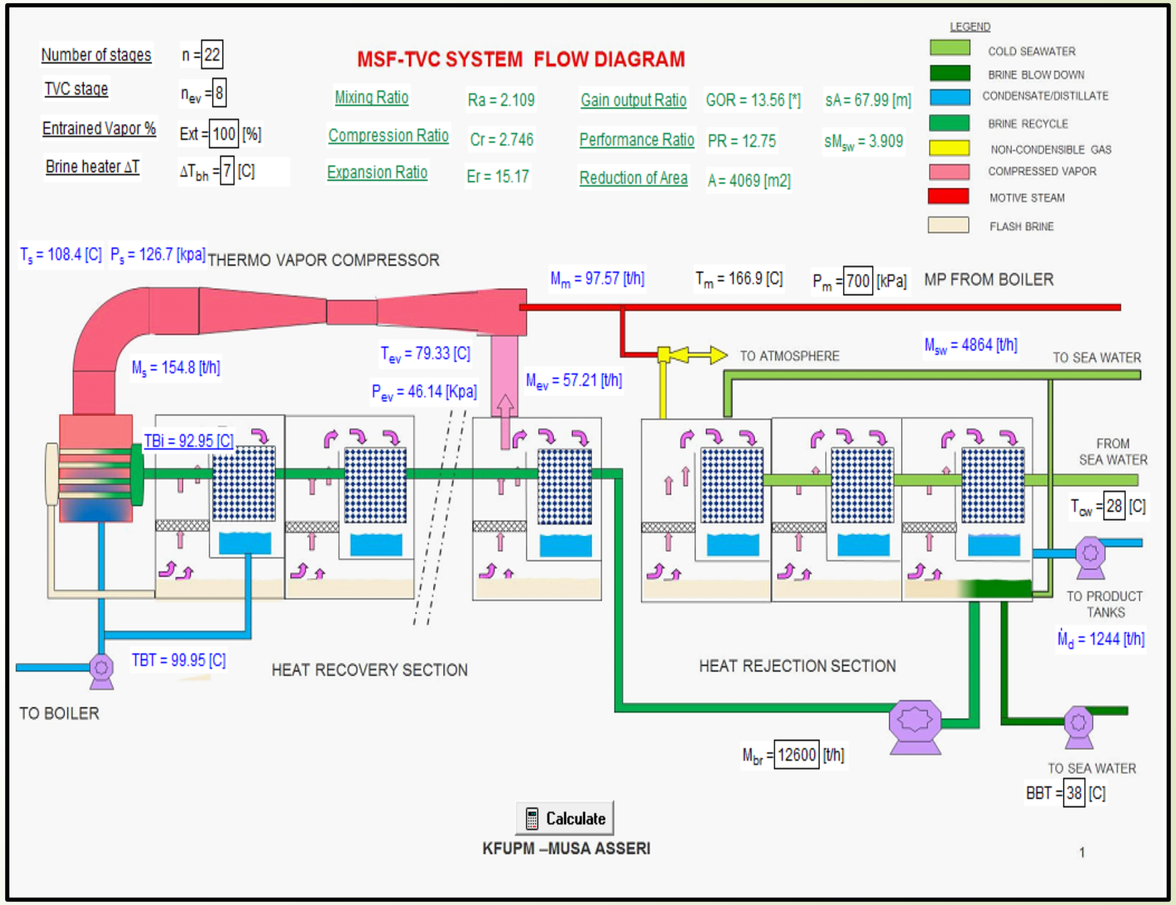
- In this work we have studied MSF-BR unit number 8 which is located in Saudi Arabia Al-Jubail plant phase -2
- The plant basically consists of 40 units and operated by Saline water corporation Company.
- The unit consists of 22 flashing stages with 19 stages in the Heat Recovery Section (HRS) and the remaining in the Heat Rejection Section(HRJS).
- Live data parameters have been taken from main control room by 1/1/2019 where the unit was working at 103 °C Top brine temperature and Bottom brine temperature 38 °C .
- The rest of main data as shown in the table

Table MSF Al-Jubail plant design /operation

No	Data	value
1	Number of stages (HRJS)	03
2	Number of Stages (HRS)	19
3	Steam consumption kg/s	145 t/h
4	Top brine temperature °C	103°C
5	brine blow down temperature °C	38 °C
6	Seawater temperature °C	28°C
7	Seawater salinity ppm	42,000 ppm
8	Brine blow down salinity (ppm)	62160 ppm
9	Seawater cooling kg/s	8920 t/h
10	Recycled brine kg/s	11939t/h
11	Make up flow rate kg/s	3105 t/h

CONFIGURATION OF MSF WITH TVC.

- The model allows for several variations such as number of stages, cooling temperature, salinity, vapor extraction percentage %, brine recycle flow conditions as well as the operation load for brine heater.
- The flow diagram includes an option to adjust brine recycle flow and motive steam pressure.
- The flow chart window is intended for analysis and variations study between conventional MSF and MSF-TVC system, since it provide the user various elements of the system.

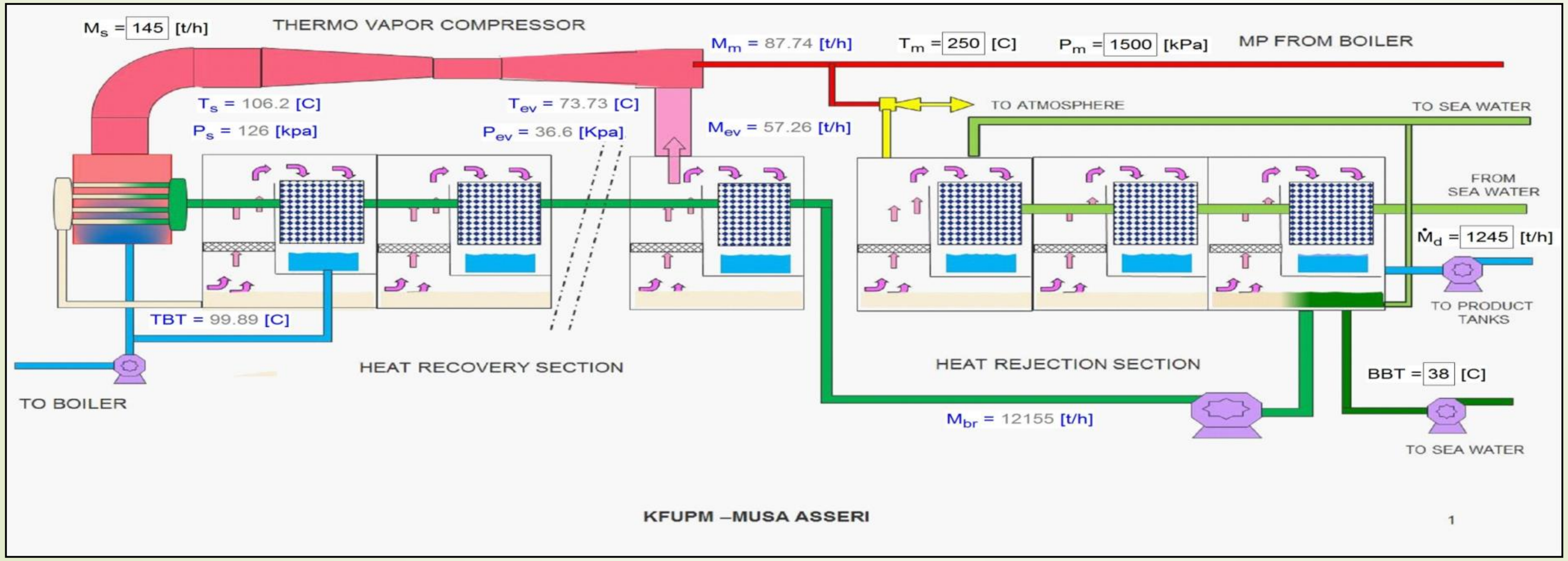


MSF-TVC flow chart window

MSF-TVC CODE SIMULATION WINDOW

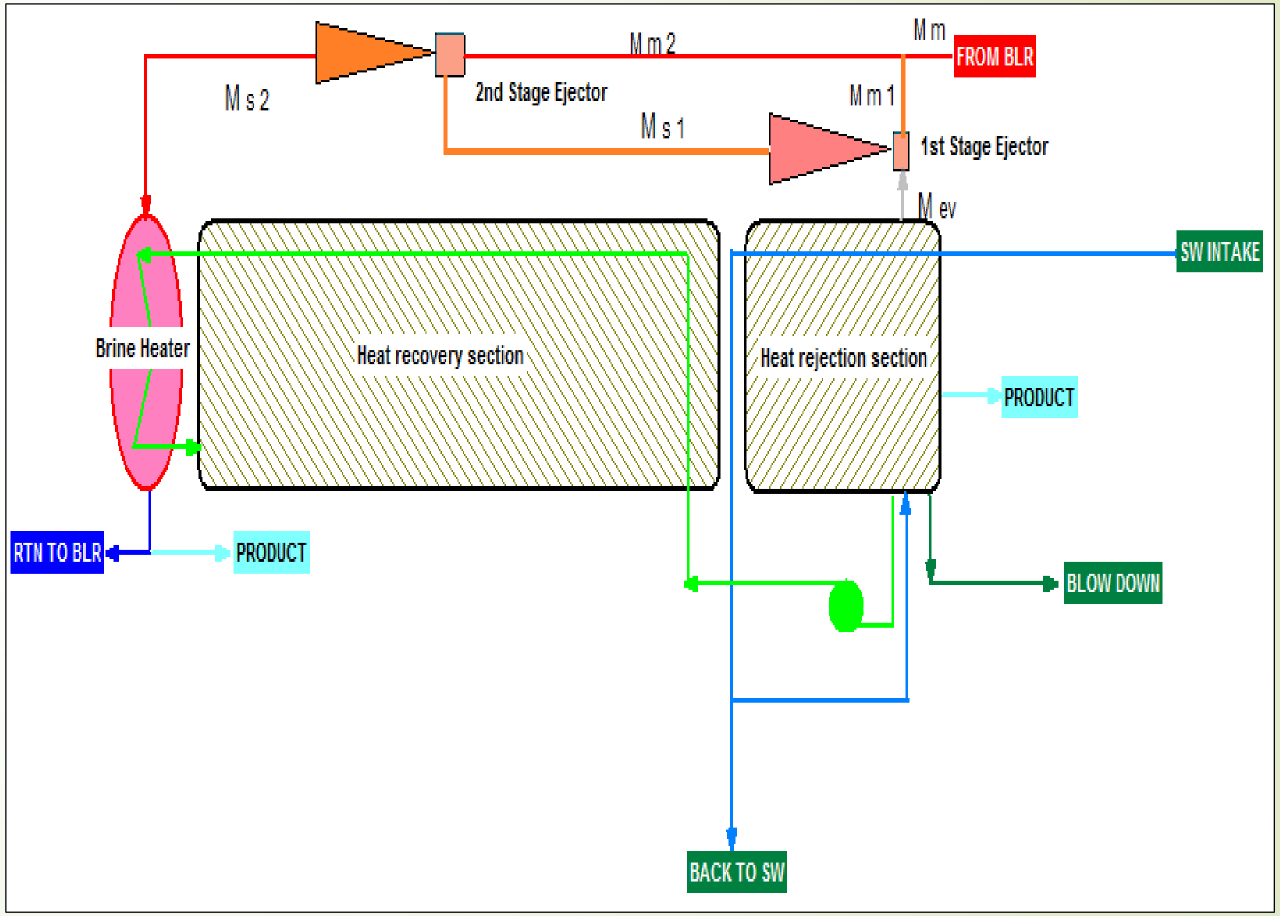
- Entrained vapor specifications from the stage are the basic key design.
- The simulation window performs many scenarios and do the important parametric studies for the process variables such as suction vapor pressure, compressed vapor pressure and temperature.

MSF-TVC flow chart window



CONFIGURATION of MSF WITH TWO TVCs IN SERIES.

- The heat rejection section is is at extremely low pressure.
- Therefore , the efficiency of the TVC is low , resulting in an inability to operate brine heater at the same required specifications.
- Therefore, we find it appropriate to study the idea of having two TVCs in series and check the possibility to deliver the same compressed vapor specifications.



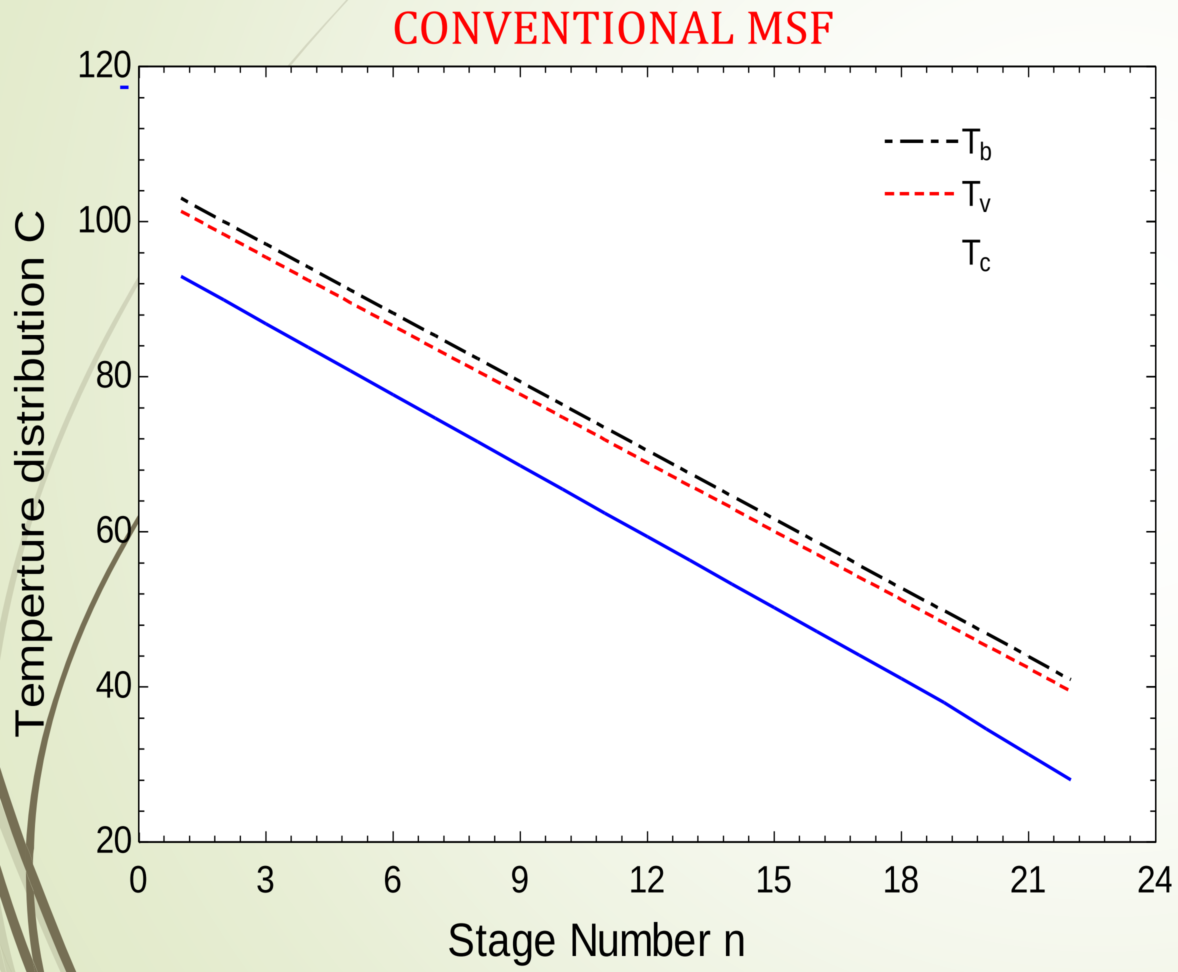
MSF-TVC with double TVC system flow diagram

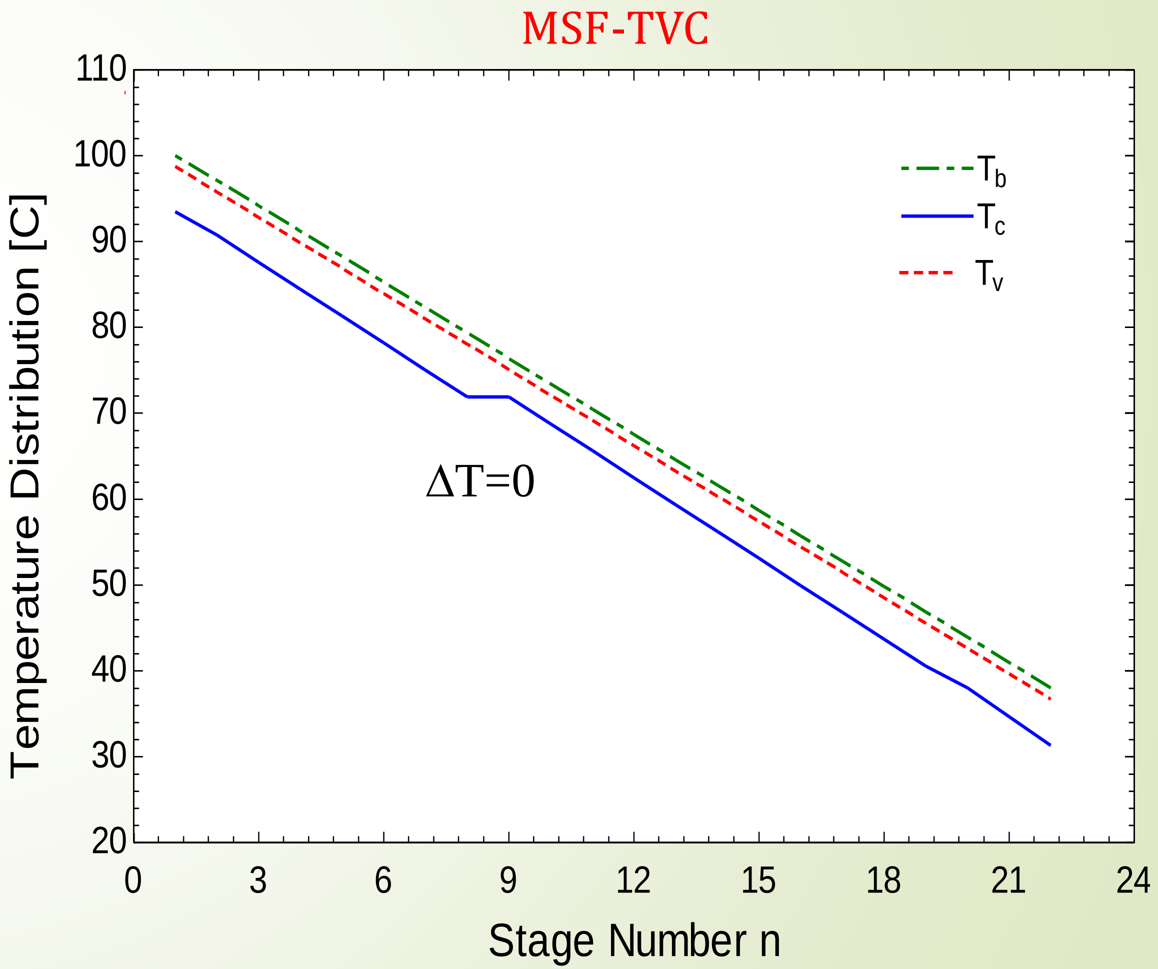
COGENERATION PLANT MODIFICATION VIEW

- Conventional MSF is a heat sink for power plant, condensing low pressure steam in the brine heater and pumps it back the condensate to the power plant again to repeat the cycle.
- In our case of MSF-TVC, we need to identify suitable pressure to extract motive steam since its pressure is playing strong role to keep the propose model more reliable and economic.

Results and Discussions

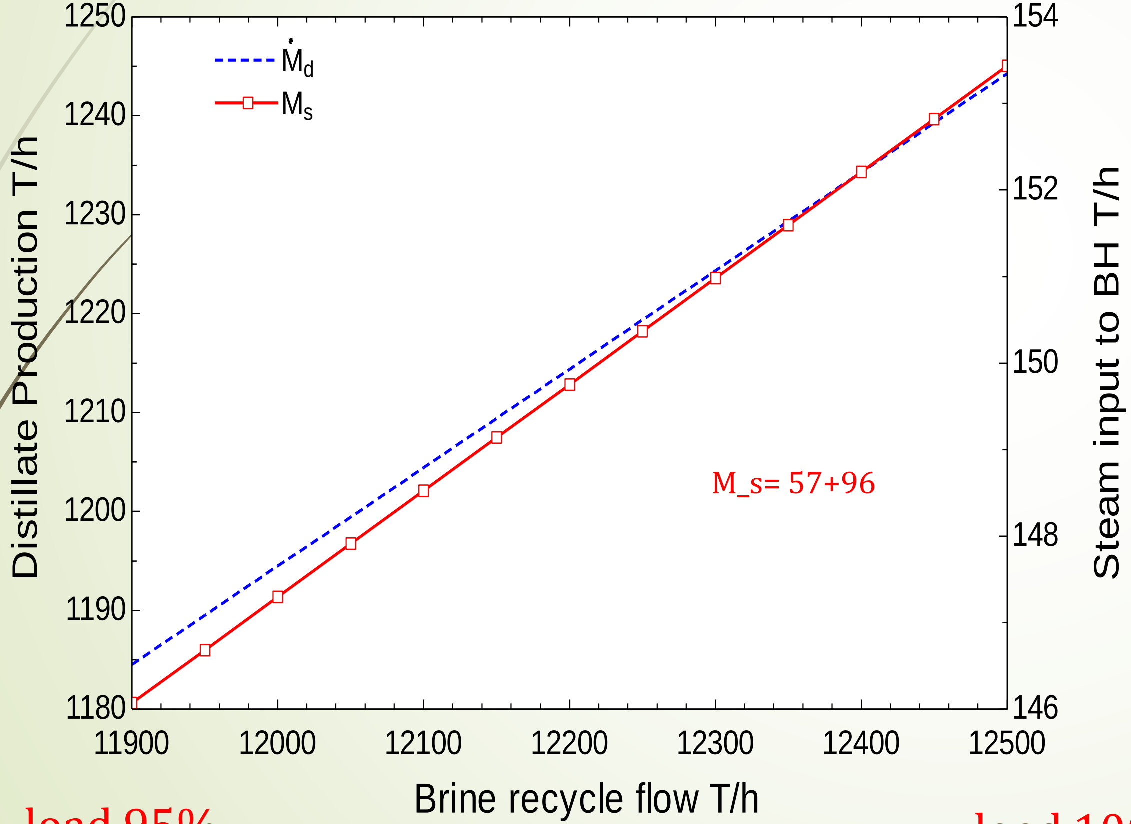
TEMPERATURE PROFILE.





Distillate production normalization

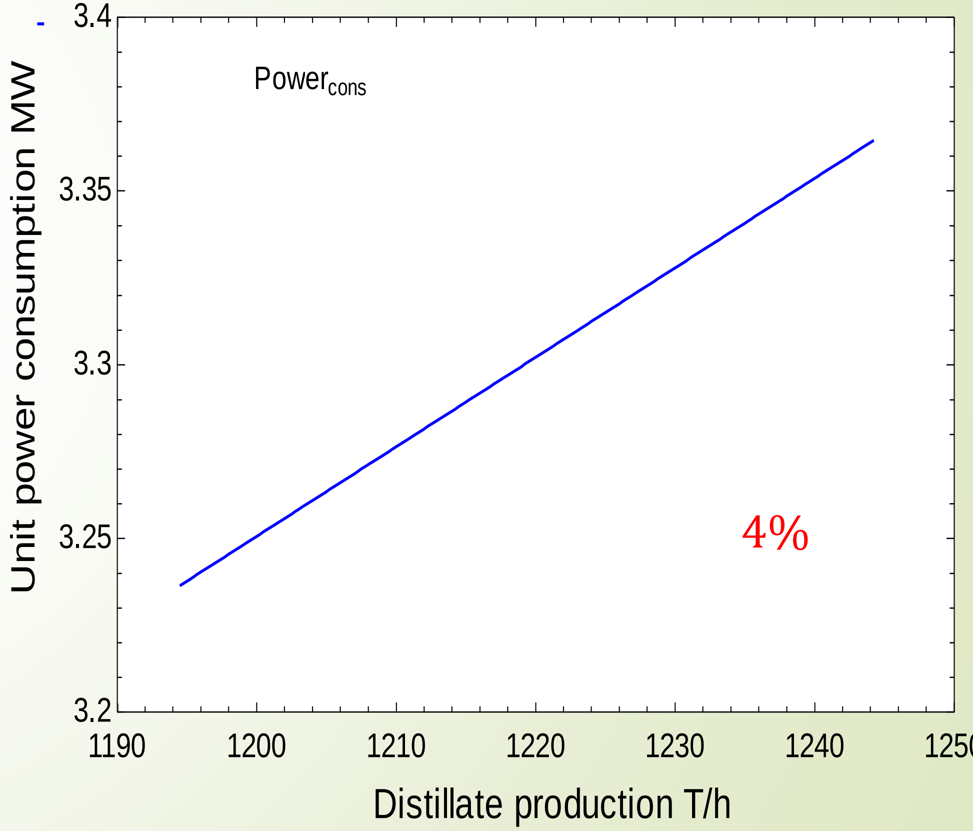
MSF-TVC load normalization



load 95%

load 100%

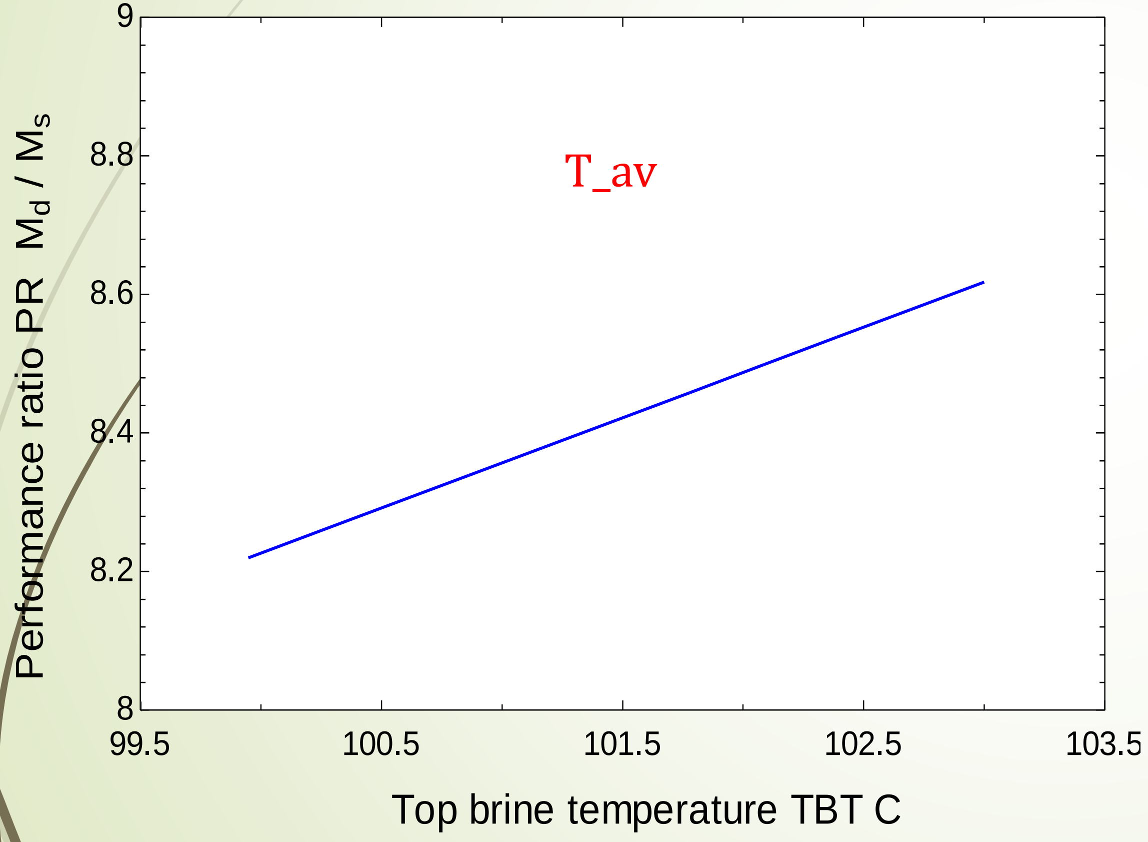
MSF-TVC power consumption



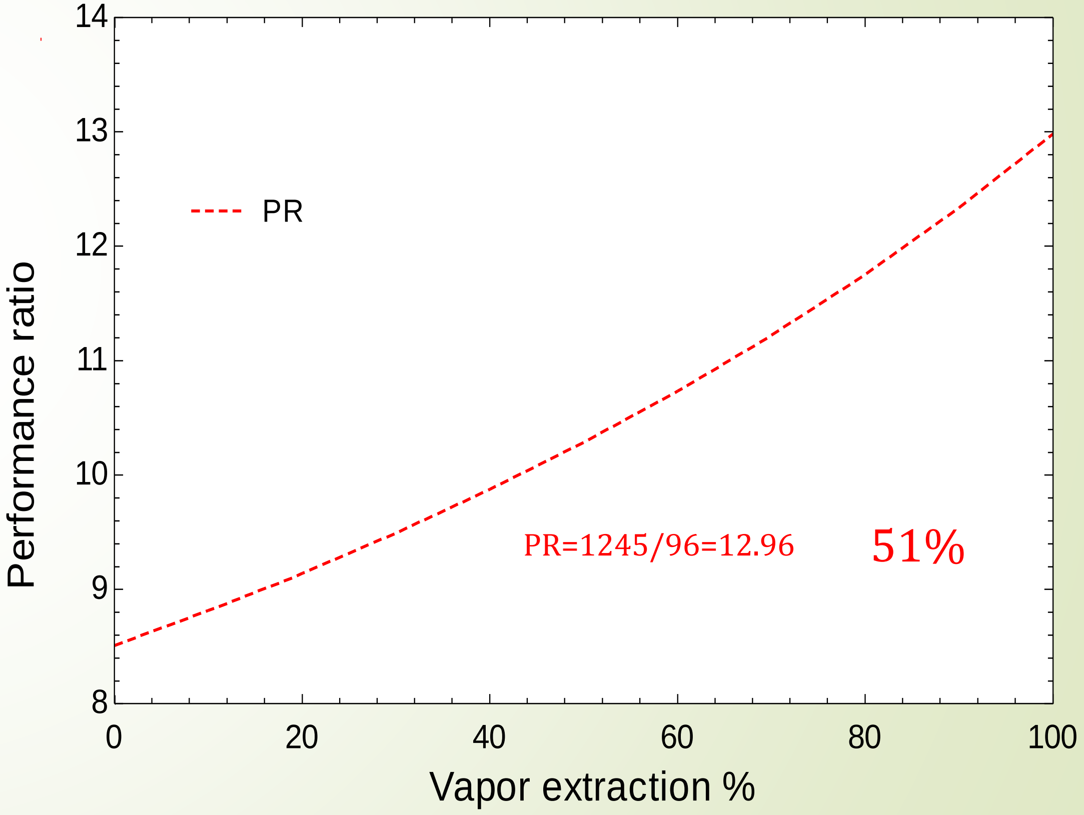
The Penalty

PERFORMANCE RATIO.

CONVENTIONAL MSF

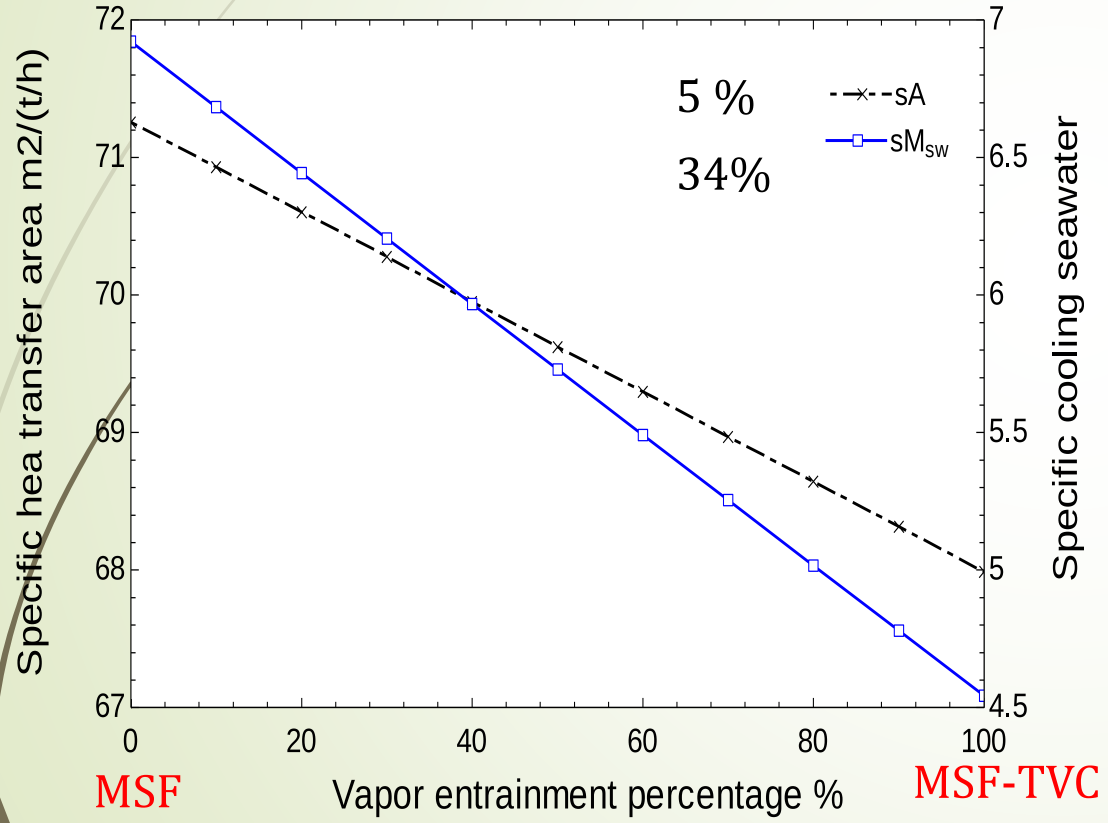


MSF-TVC AT STAGE 8

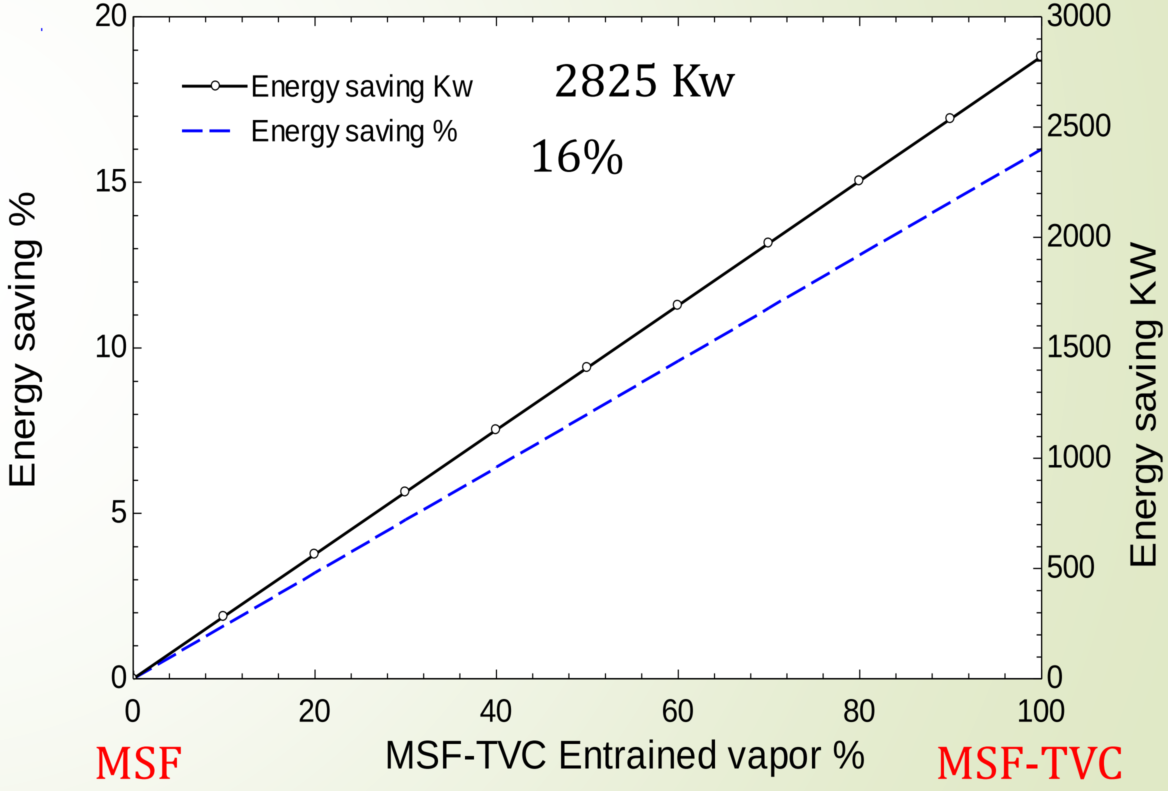


Effect on Energy Requriements.

Specific cooling water and specific heat transfer area



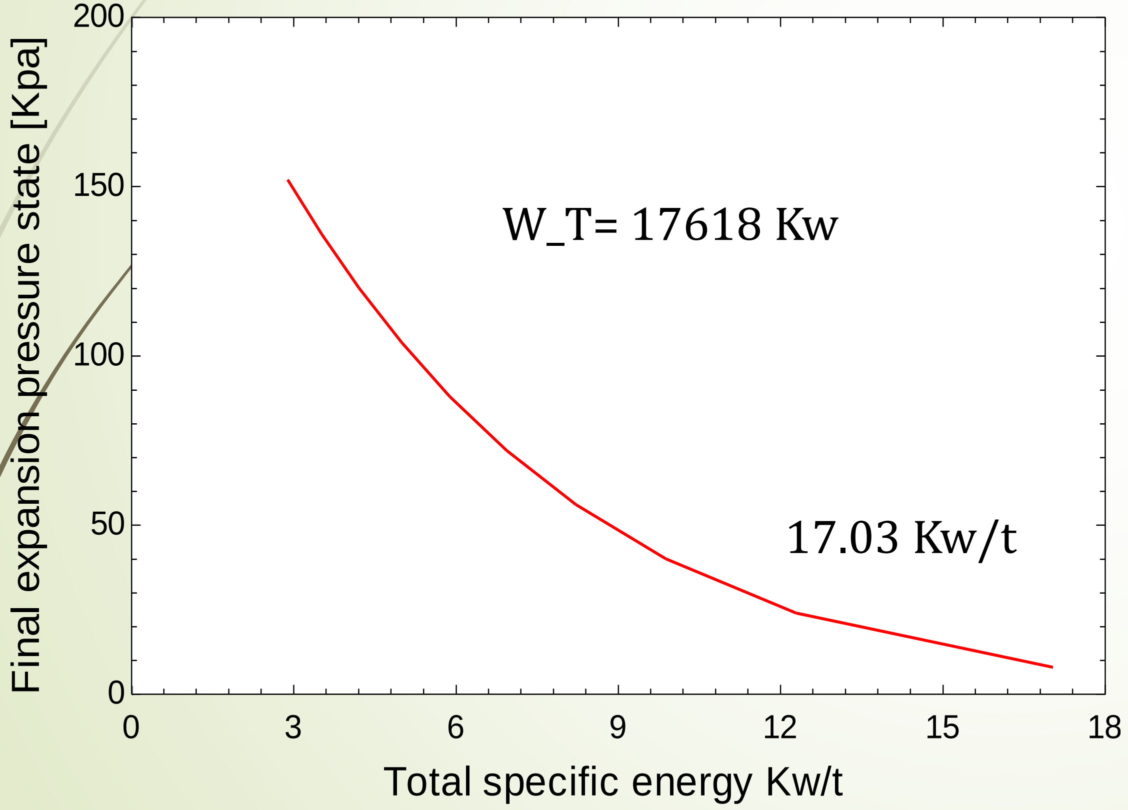
Energy saving



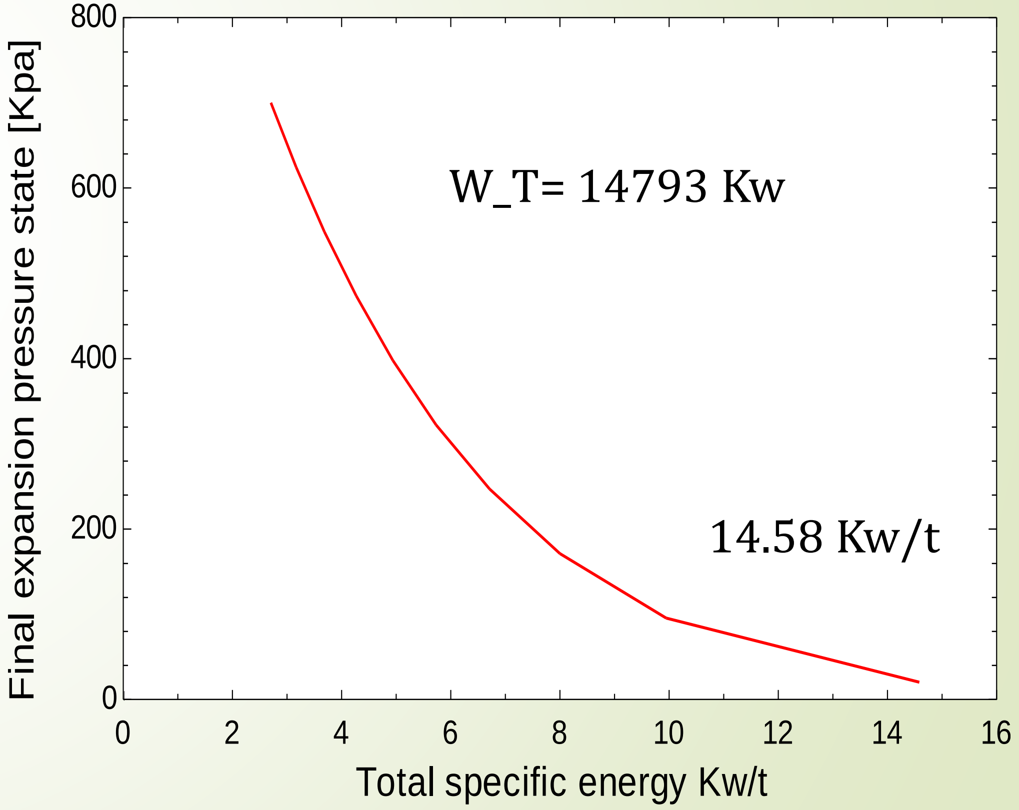
Work loss.

The variation of total specific energy as a function of final expansion pressure kPa.

CONVENTIONAL MSF



MSF-TVC AT STAGE 8



Al-JUBAIL PLANT MSF AND MSF-TVC COMPARISON

Table 9 The comparison between MSF and MSF-TVC 100% load for the important process variables.

Parameter	Conventional MSF	MSF-TVC 100% -stage 8	STUDY OUTCOMES
performance ratio	8.58	12.97	Improvement 51%
Steam consumption t/h	145 LP	96 MP	Reduction 33%
Reduction of area m2	----	4092 m2	Reduction 4.58%
Specific cooling flow rate	6.924	4.544	Improvement 5%
Specific heat transfer area t*m2/h	71.26	67.99	Improvement 4%
Brine recycle flow t/h	11922	12508	Increased 5 %
TBT °C	103	100	Reduced 3 degrees
Cooling sea water flow rate t/h	8700	5658	Improvement 34%
Production flow rate t/h	1245	1245	fixed
Compressed vapor pressure kPa	130	124	Fair enough
Pumps loads MW	3.448 MW	3.337 MW	Improvement 4%

Thank you

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