WTIIRA

The Research and Development Center was established in 1987. From 2007 to 2015, several key decisions were made to better enhance the Center, such as restructuring and rebranding the Center into the Institute for Research and Desalination Technologies. The Institute is the only research body across the region specialized in the desalination industry research; it seeks to reach global leadership in water technologies and lead innovation in desalination technologies, aimed at producing water in such manners that ensure sustainability, high-efficiency, low-cost, and continuum for everyone, everywhere, by 2030.

Strategies

Driven by the Center's goals, aimed at supporting water desalination industry in the Kingdom of Saudi Arabia and beyond under the umbrella of SWCC, the Institute's strategies are based on the following:

Ras Al Khair-SWCC

- Saline Water Conversion Corporation's (SWCC) Ras Al Khair Desalination Plant is a hybrid desalination plant that implements both the multistage flashing (MSF) and reverse osmosis (RO) technologies. The plant is located in the Ras Al Khair Industrial City.

- Construction of the desalination plant started in early 2011 and commissioning was held in April 2014. It is the biggest desalination plant of its kind in the world, capable of serving approximately 3.5 billion people in the city of Riyadh.

- The plant has a capacity to produce more than 1 million m3/day

Ras Al Khair-SWCC

RAK Plant

MSF plant
Capacity : 700,000 m3/day

RO plant
Capacity: 345,000 m3/day
16 Train
ERD: turbo charger
ERD efficiency :80%

Objective

The primary objective of conducting an investigation aimed at saving energy and reducing emissions is to identify, analyze, and implement strategies and measures that lead to more efficient resource utilization, reduced environmental impact, and enhanced sustainability. This investigation seeks to:

- Identify Energy Efficiency Opportunities
- Optimize Operational Practices
- Compliance with Regulations
- Cost-Benefit Analysis
- Promote Sustainability

Background

- WTIIRA has studied the process within the membrane section starting from booster pump till energy recovery device

- This study was initiated to investigate the possibilities of improving the efficiency of the energy recovery device in RAK. The existing device used is the turbo charger, which has a nominal efficiency of 80% but after investigation < 70% efficiency was achievable.

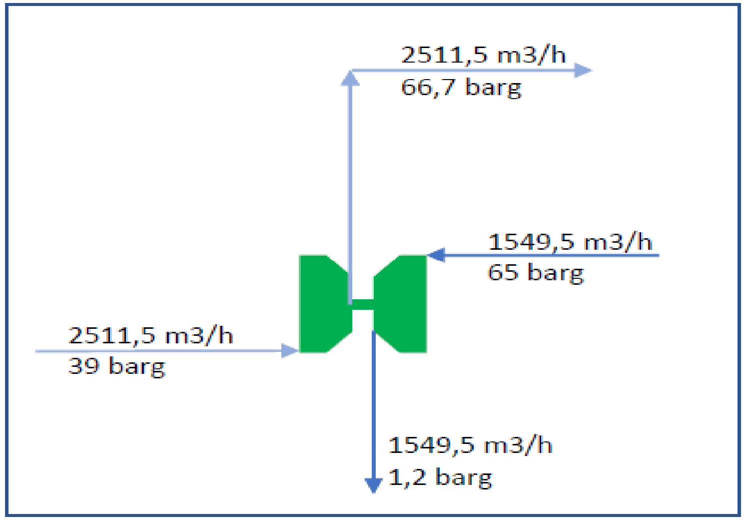
Methodology

- Data Collection: The investigation began with a thorough examination of historical operational data, including flow rates, pressure levels, and energy consumption patterns. This data provided valuable insights into the deviation from the expected efficiency.
- Physical Inspection: A physical inspection of the turbocharger system was conducted. Visual examination revealed no obvious mechanical issues, but the focus shifted to the hydraulic components, particularly the nonreturn valve.
- Nonreturn Valve Inspection: The nonreturn valve, located in the hydraulic system before the turbocharger, was carefully examined. It was discovered that the valve was not fully open, leading to increased resistance in the hydraulic line. This restricted flow and resulted in a drop in pressure before the turbocharger.
- Pressure Analysis: Pressure gauges were installed at various points along the hydraulic line to measure pressure differentials. The readings confirmed a noticeable drop in pressure before the turbocharger, substantiating the suspicion that the nonreturn valve was causing hydraulic inefficiencies.
- Efficiency Testing: After the hydraulic system was repaired, efficiency testing was repeated. The turbocharger's performance approached to its nominal efficiency of 70%, validating the success of the corrective measures

Current status

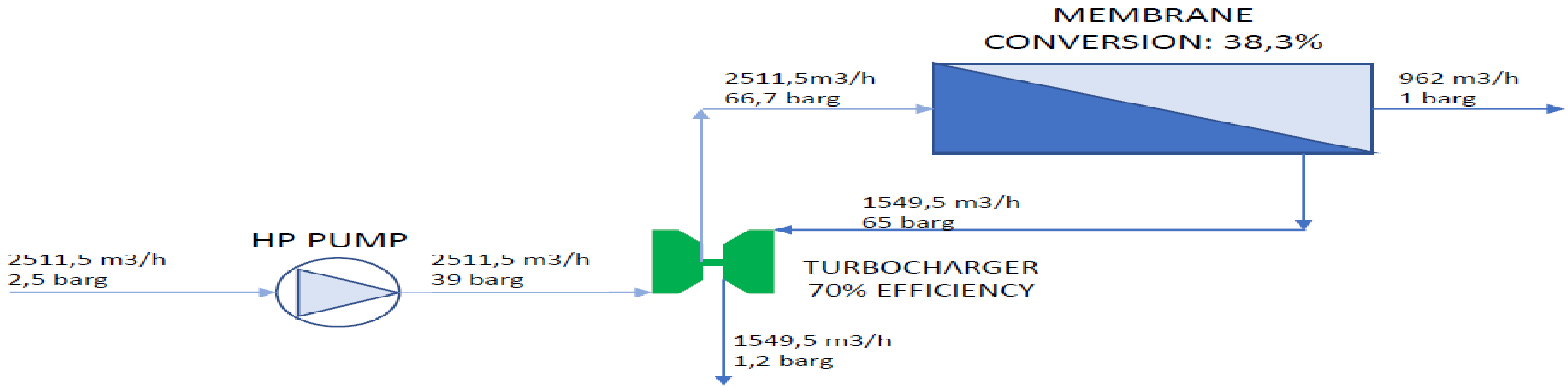
- The system consist of 17 identical train, with TURBO CHARGER , Each turbo charger is powered by 1549.5 m3/hr of pressurized brine which exchange pressure with 2511.5 m3/hr of fresh seawater and lead to increase in pressure from 39 bar to 66.7 bar

Equipment Number	:	81 GEH 11-19 AP002, 82 GEH 11-18 AP002
Quantity	:	17 unis
Model	:	HPBe 2800
Maker	:	FEDCO
Type	:	Turbocharger
Normal Flow rate	:	2,568 m3/hour
Suction Pressure	:	34.4 bar g
Discharge Pressure	:	68.6 bar (g)
Boosting Pressure	:	34.2 bar (g)
Operation Mode	:	16 in operation 1 standby
Noise Level	:	85 dBA
Efficiency @ Normal Flow	:	80 %
Speed @ Normal Flow	:	4300rpm



Current status

- Although actual turbo charger efficiency as mentioned in the data sheet is 80%, actual reading which are shown in figure to lead to < 70%
- Turbo charger power efficiency calculation:
  - => 2511,5*(66,7-39) = TC eff [%] *(1549,5* (65-1,2)) =>
    - Permeate Flow = Feed Flow-Brine Flow= 962 m3/h
      - Membrane conversion = 962/2511,5 = 38,3%
  - Calculated TC eff [%] = **<u>70,37% vs 80% theoretical eff.</u>**



Operational modification

You will see that the valve location is only at the 5.5 marker which is only 37% open. Looking at the NRV design and operating position, **we believe there is a large amount of pressure being lost across this NRV (2 to 5 bar) could be verified by** installing a pressure gauge 2 feet or so, after the Victaulic connection on the turbo.

This pressure could be saved and with high flow it would be reflect directly to the power cost (600 kwh for each 0.5 bar)

Saving method suggestions

There are two methods for saving suggested for this situation

1- power saving: power can be saved by reduction the pumping since the turbo charger efficiency will be increase by open the valve so pumping energy can be decrease to get similar production value, and since there is no VFD installed in high pressure pumps so decide to reduce the pumping from filtrate (poster) pumps

2- increase production: by increase the pressure more that operational design, however there is limitation in the feed pressure membrane

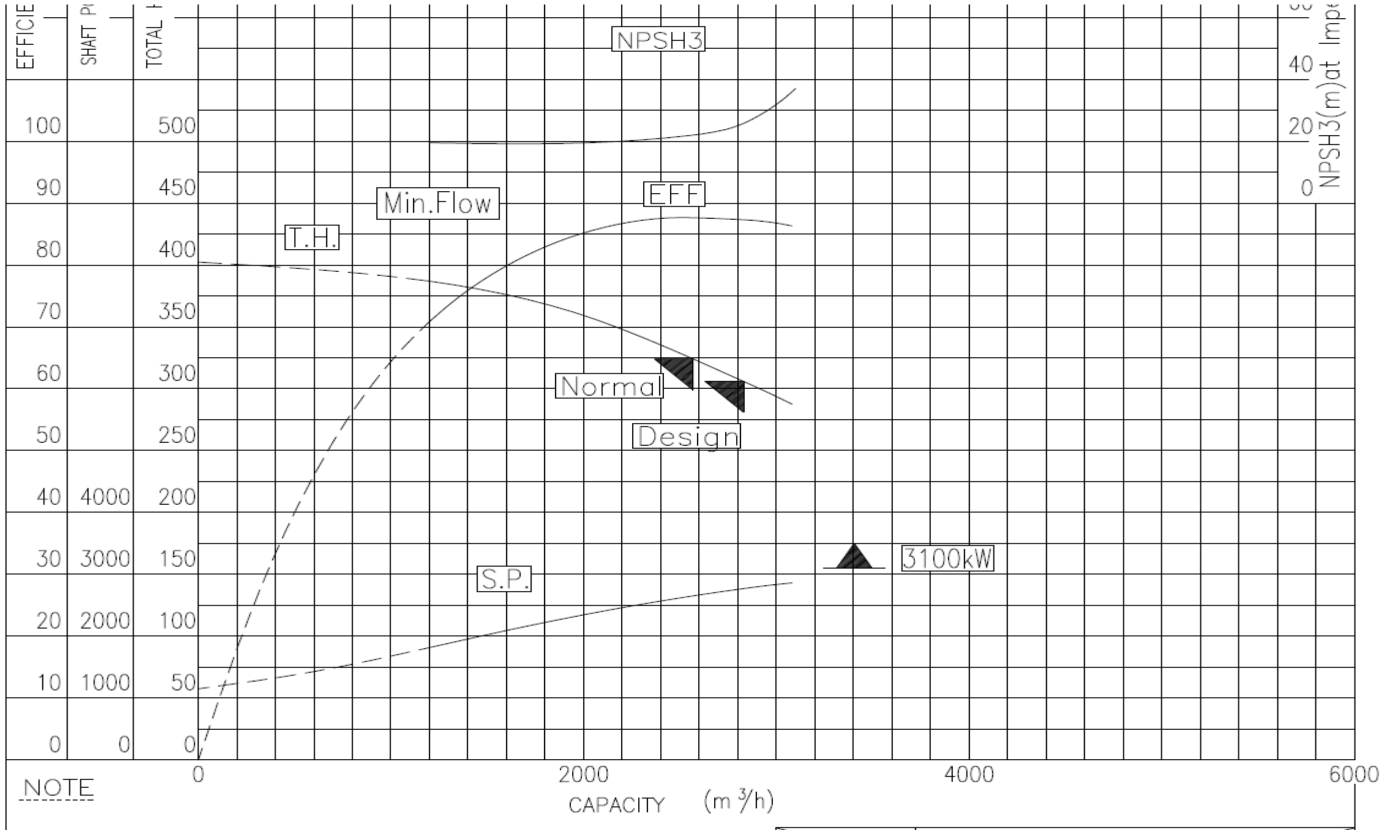
Challenges

Challenges	Mitigation
Turbo charger warranty, membrane specs., valave and pumps NPSH	Checked
Header feed to different trains	Hydraulic system will be balanced through booster pump turbo charger
Determine exact improvement	installing a pressure gauge 2 feet or so, after the Victaulic connection on the turbo.

Challenges

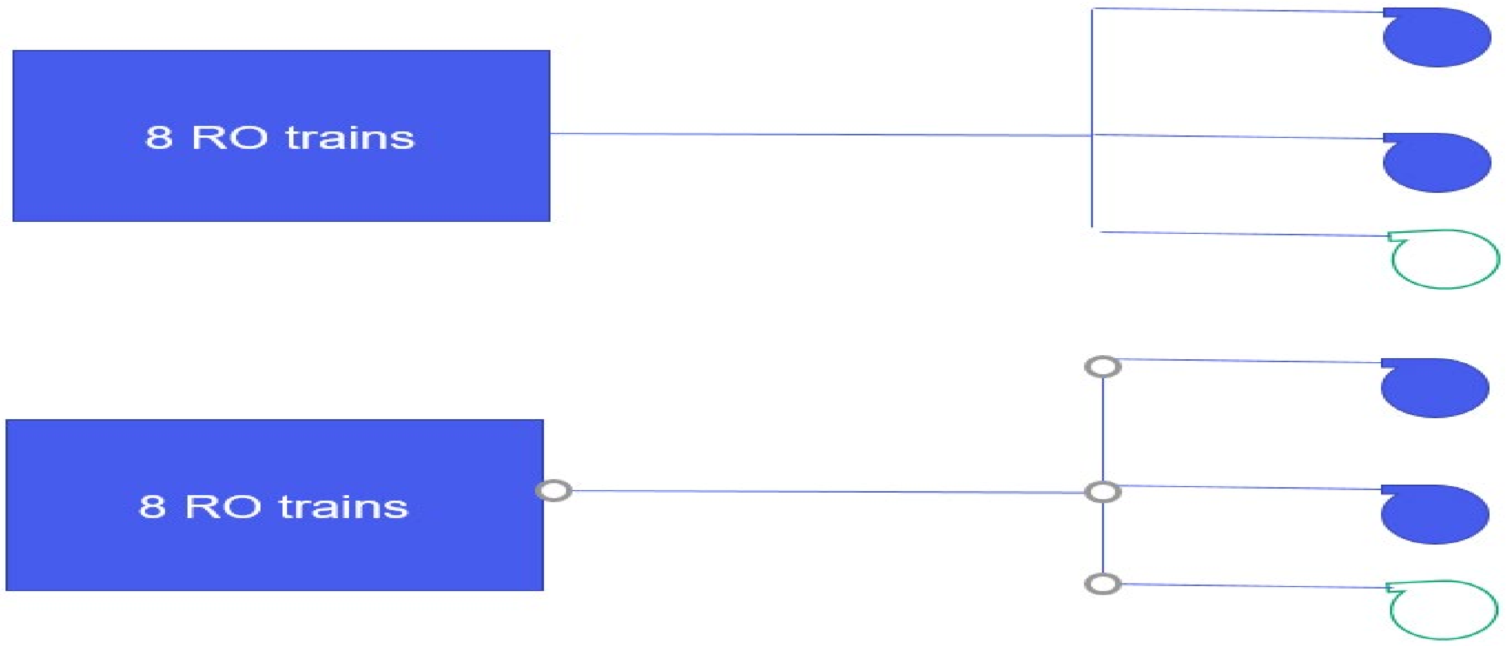
13	NPSHav @Impeller Eye	45 m	Max.Suc.Press. 6.7 (bar g)
14	NPSHre @Impeller Eye	@Rated flow ; 25.0 m	@Max. flow ; 37.0 m

As depicted in Table and corroborated by the characteristic curve, it is evident that the necessary Net Positive Suction Head (NPSH) for the system is 25 meters. In the scenario of maximum flow, this requirement increases to 37 meters. Fortunately, based on the information provided in the catalogue, the available NPSH is generously provided at 45 meters.



Challenges

The figure below it shows the configuration of the plant since there are 2 filtrate pumps feeding header for 8 train RO plant, all hydraulic system shall be studied to not effected in another train since rectify the position of the valve.



Test Results

Valve opening %	9/14 %64	5/14 35%
Motor valve open%	%63.4	%63.4
Flow M3/hr	2603	2603.7
Pressure after turbo bar	64	63.5
Brine pressure after membrane bar	63.4	62.8
Product m3/hr	910	899
Conductivity Micro s	2375.7	2425

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Test Results

A comparison between the original unit state and the condition after partially opening the valve and returning the automatic valve to its original position revealed an increase in production from 899 to 910.1, marking a 1.23% increase in product output. Additionally, the turbocharger efficiency rose from 65% to 70%. It's worth noting that the valve did not fully open, resulting in a 2.7% decrease in the produced water salinity due to an increase in feed pressure by 1.3%. This confirms the initial study's indication of the potential to enhance efficiency and increase production.

Production increase 1.23%

ERD efficiency increase 5%

Salinity of product decrease 2.7%

Conclusion and Recommendation

- By investigation found there is problem in turbo charger efficiency which effecting of Train efficiency
- Test has been conducting to confirm effecting of NRV position to the ERD efficiency
- The test shows increasing production by 1.23% and enhancement in ERD efficiency by 5% with out any operational cost
- The hydraulic study shows there is a gap of improvement can be achieved by changing NRV position in safe operation condition
- There is difficulty to increase production more than 910 from membrane view
- Finally it is recommended to open the NRV to 90% and increase the production to safe limit however extra saving can be done by controlling the poster pump

Thank you