DME S-006-2013 – Lecture 06

DME GERMAN DESALINATION

More Water at Lower Cost: Up-rating of M.S.F. Desalination Plants

Dr. Eng. Aldo Massarani
Bilfinger Deutsche Babcock Middle East

DME - Seminar
Key Solutions for Key Markets

December 03rd, 2013
Jeddah – Saudi Arabia

1-3 DECEMBER 2013, JEDDAH HILTON, SAUDI ARABIA
SWPF 2013 المنتدى السعودي للمياه والطاقة SAUDI WATER & POWER FORUM

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More Water at Lower Cost: Up-rating of M.S.F. Desalination Plants

The dilemma for existing Desalination Plant……

1. Constrained water production
2. Operating margins

How do we get there……

1. Increase production – up rating the Brine Recycle Flow
2. Improve efficiency – up rating the G.O.R

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Technical Solution to Problem 1
Increasing Water Production Capability

Production of a desalination plant is directly proportional to the product of brine recycle flow and the temperature difference between the top brine temperature and the bottom brine temperature, as follows:

$$P = k \times G_{recycle} \times (TBT - BBT)$$

Since the bottom brine temperature is strictly a function of the sea water temperature and since the top brine temperature cannot be increased without reducing the operation margins set by scaling mitigation. The only way to increase the distillate production is thus to increase the brine recycle flow.

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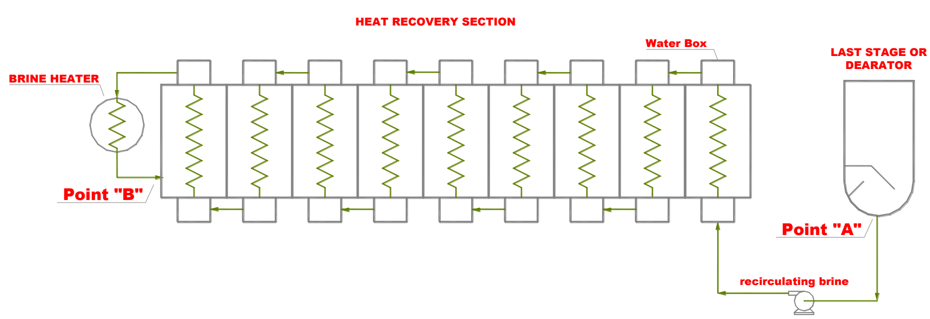
Technical Solution to Problem 1
Increasing Water Production Capability

Typical brine recycle circuit of M.S.F. Desalination Plants



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Technical Solution to Problem 1
Increasing Water Production Capability

So how can we increase the brine recycle flow then ?

1. Remove or reduce any restriction in the brine recycle circuit
2. For early generation plant, de-load the brine recycle pump by adding a dedicated brine blow down
3. Optimize the brine recycle circuit

Of course, a combination of the above methods will have best results. The up-rating strategy will be defined through a comprehensive process investigation of the plant.

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Technical Solutions
Option 1: Improved Brine Recycle Circuit

The Improved Brine Recirculation Circuit

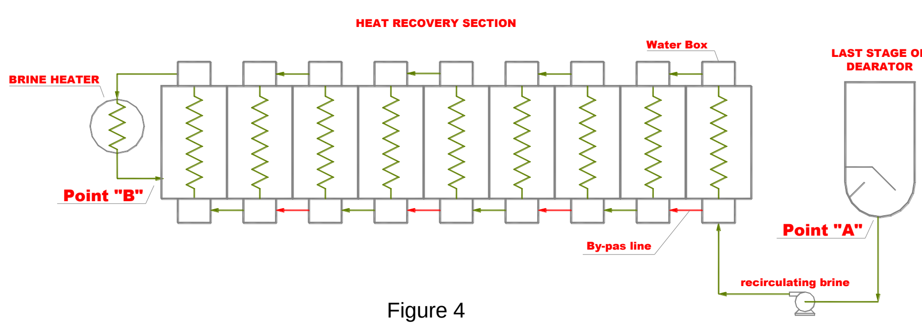

Figure 4

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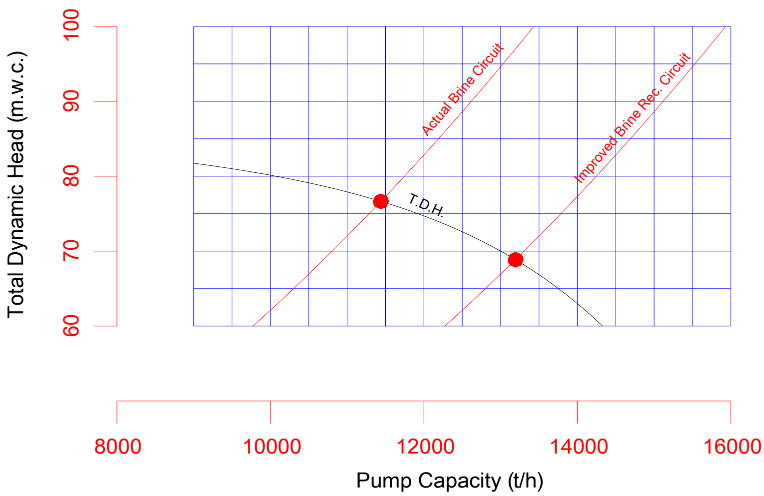

Figure 6

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TEMPERATURE DIAGRAM

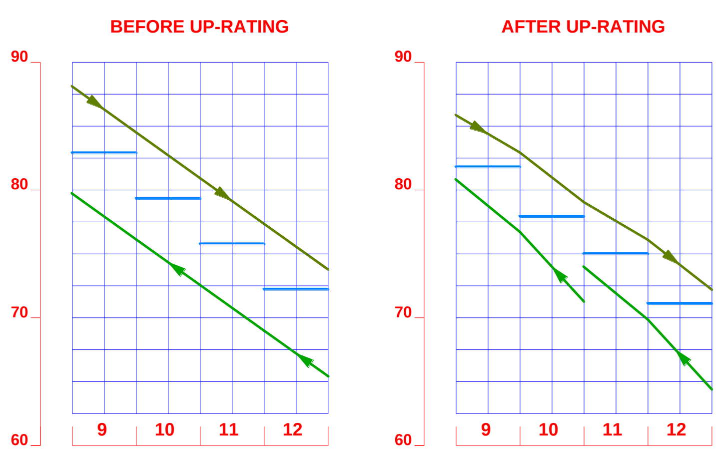

Figure 8

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Technical Solution to Problem 1
Case Study UAE

MSF Plant 19 Stages (U.A.E.)
Comparison Table

		Reference Heat Balance	Improved Solution with IBRC & STRS	Difference	
				absolute	(%)
Sea Water to Heat Reject Section	t/h	8300.00	8300.00	0.00	0.00
Sea Water to Vacuum System	t/h	481.00	481.00	0.00	0.00
Total Sea Water Flow	t/h	8781.00	8781.00	0.00	0.00
Top Brine Temperature	°C	110.00	110.00	0.00	0.00
Sea Water Temperature	°C	35.00	35.00	0.00	0.00
Brine Recycle Flow	t/h	14300.00	17100.00	2800.00	19.58
M.P. Steam for Brine Heater	t/h	155.70	143.94	-11.76	-7.55
M.P. Steam for Vacuum System	t/h	3.60	3.60	0.00	0.00
M.P. Steam for STRS	t/h	0.00	10.00	10.00	---
Total M.P. Steam Requirement	t/h	159.30	157.54	-1.76	-1.10
Distillate from last stage	t/h	1407.00	1714.50	307.50	21.86
High Purity Distillate from B.H.	t/h	0.00	20.00	20.00	---
Total Distillate Flow	t/h	1407.00	1734.50	327.50	23.28

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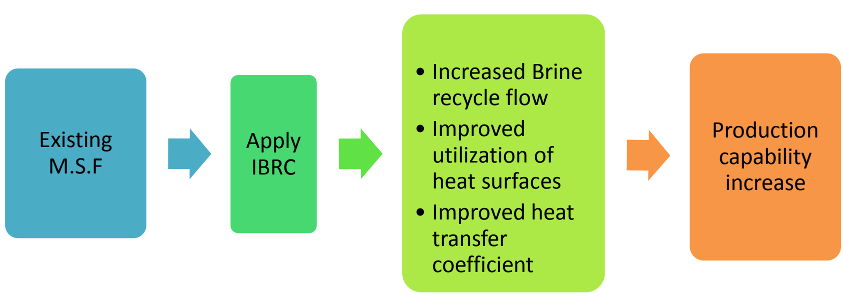
Technical Solution to Problem 1
Increasing Water Production Capability



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Technical Solution to Problem 2
Increasing Water Production Efficiency

This modification aims to increase the plant efficiency (G.O.R).

Simply stated, in the "Improved Steam Supply System" (STRS), steam produced in a heat recovery stage is extracted and sent back to the Brine Heater. Steam required for the desalination process is thus saved hence increasing plant G.O.R. and efficiency.

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Technical Solution to Problem 2
Increasing Water Production Efficiency

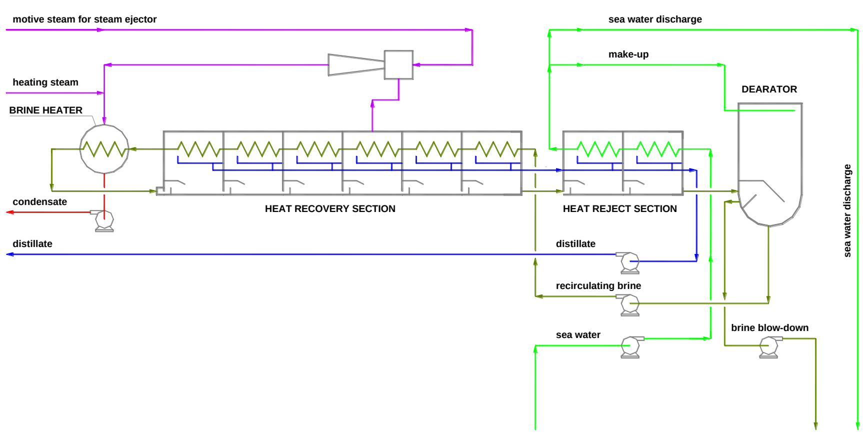

Figure 9

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Technical Solution to Problem 2
Increasing Water Production Efficiency

Validation Example

If the distiller needs 100 t/h of steam for the Brine Heater, with the Steam Recirculation system we can reduce the total amount as follows:

Suppose 15 t/h of steam is extracted from a stage. In order to pump it back into the BH, 15 t/h of ejector motive IP steam will be required.

In this case the total amount of steam for the desalination purpose will be:

- 70 t/h of LP steam + 15 t/h of IP steam = 85 t/h

The saving is thus,

- 15 t/h sourced from STRS system.

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Technical Solution to Problem 2
Case Study 1 MSF Plant Kuwait

MSF Plant 24 Stages (KUWAIT)
Comparison Table

		Reference Heat Balance	Improved Solution with STRS	Difference absolute	Difference (%)
Total Distillate Output including the High Purity Distillate	t/h	1,180.00	1,218.40	38.40	3.25
Sea Water Temperature	°C	32.20	32.20	0.00	0.00
Sea Water Flow to Heat Rejection Section	t/h	10,420.00	10,420.00	0.00	0.00
Top Brine Temperature	°C	104.00	104.00	0.00	0.00
Total Heat coming from the System	MJ/h	370,637.19	288,398.55	-82,238.63	-22.19
Total Heat Returned to the System	MJ/h	50,505.11	38,318.15	-12,186.96	-24.13
Total Heat Consumed by the Distiller	MJ/h	320,132.08	250,080.40	-70,051.68	-21.88
Specific Heat Consumption	KJ/Kg of distillate	271.30	205.25	-66.05	-24.34
Performance Ratio including steam to vacuum system	Kg/2326 KJ	8.57	11.33	2.76	32.18
Overall Steam Demand (excluding the vacuum System)	t/h	106.64	81.98	-24.66	-23.12
G.O.R. Referred to the Overall Steam Demand	Kg/Kg	11.065	14.862	3.80	34.31

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Technical Solution to Problem 2
Case Study 2 MSF Plant Oman

MSF Plant 20 Stages (Oman)
Comparison Table

		Reference Heat Balance	Improved Solution with STRS	Difference absolute	Difference (%)
Total Distillate Output including the High Purity Distillate	t/h	1,585.00	1,585.60	0.60	0.04
Sea Water Temperature	°C	30.00	30.00	0.00	0.00
Sea Water Flow to Heat Rejection Section	t/h	11,100.00	11,100.00	0.00	0.00
Top Brine Temperature	°C	108.00	108.00	0.00	0.00
Total Heat coming from the System	MJ/h	528,877.26	430,980.08	-97,897.18	-18.51
Total Heat Returned to the System	MJ/h	93,991.79	79,501.17	-14,490.61	-15.42
Total Heat Consumed by the Distiller	MJ/h	434,885.47	351,478.90	-83,406.56	-19.18
Specific Heat Consumption	KJ/Kg of distillate	274.38	221.67	-52.71	-19.21
Performance Ratio including steam to vacuum system	Kg/2326 KJ	8.48	10.49	2.02	23.78
Overall Steam Demand (excluding the vacuum System)	t/h	190.80	155.30	-35.50	-18.61
G.O.R. Referred to the Overall Steam Demand	Kg/Kg	8.31	10.21	1.90	22.91

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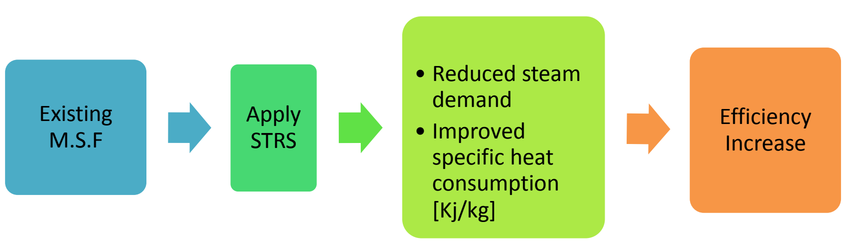
Technical Solution to Problem 2
Increasing Water Production Capability



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Technical Solutions
Cost of Fresh Water with Different Technologies

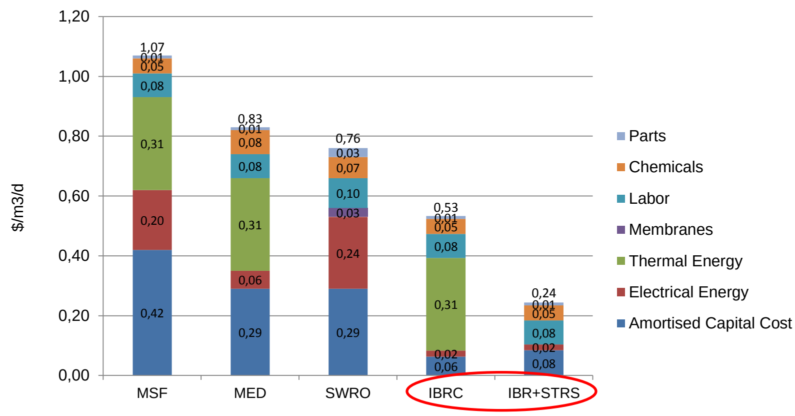

Figure 11

Source: GWI magazine dated October 2012

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Conclusion
Up-rating has economic advantages over New Built

The major advantages are:

1. Low capex investment
2. No additional space is necessary
3. No additional sea water demand
4. No additional major equipment = water produced free of maintenance cost
5. Reduced specific operational requirements
4. Reduced specific electrical consumption
5. Lower implied CO2 emission (no additional boilers are required)

Dr. Eng. Aldo Massarani
Bilfinger Deutsche Babcock Middle East