Heavy Industries & Construction

RO pilot plant내의 2 stages DMF 성능 실험

(Performance Test of 2 stages DMF in Reverse Osmosis Desalination Pilot Plant)

최 석호, 임 지섭, 우 성우, 권 철오

두산 중공업

1. Summary

Summary of DMF pilot tests

- Conventional type DMF as pretreatment for RO plant has reliability, economic and prevalence.
- RO plant is required to be optimized with pilot test for seasonal variation.

Objectives of DMF pilot tests

- Set up the pilot test program in Middle East Site
- Optimize the process design of the conventional pretreatment (media filter)
- Optimize the chemical consumption($FeCl_3$, polymer) and operation condition

Main concerns of pilot test

- Coagulation-flocculation in DMF
- Media filtration in terms of seawater characteristics

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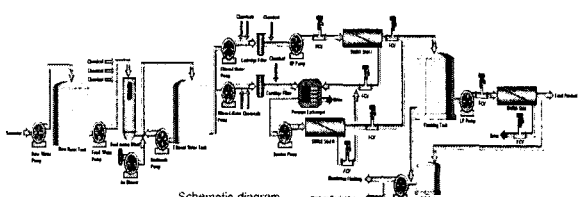
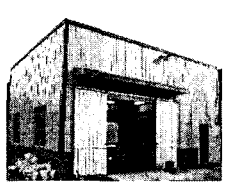
2. Description of Pilot Plant



Schematic diagram



Building

- Construction Period : March 11, 2004 ~ June 30, 2004
- Skid Configuration : Raw Water Pump Skid + Pretreatment Skid + Reverse Osmosis Skid (SWRO + BWRO)
- Plant Specification
  - Plant Capacity : max. 45 m^3/d
  - Dual Media Filter : 4 unit, 1.2 ~ 1.8 m^3/hr each
  - SWRO Unit : 4" x 12 membrane, 35 ~ 45%, 1.6 ~ 2.1 m^3/hr
  - BWRO Unit : 4" x 6 membrane, 75 ~ 90%, 1.2 ~ 1.9 m^3/hr
  - Energy Recovery : Pressure Exchanger, PX-15 (ERI)

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3. Sea water quality

- Higher SDI, turbidity, TOC, algae, bacteria values in Masan bay than in Middle East. And TDS has opposite feature.

Seawater quality comparison

Item	Unit	Pilot plant in Masan bay (2005)	Pilot plant in Middle East (UAE, 2002)
Mg^{2+}	mg/liter	1130	1337
Ca^{2+}	mg/liter	359	801
Ba^{2+}	mg/liter	0.03	0.5
Sr^{2+}	mg/liter	6.59	30
Fe^{2+}	mg/liter	0.03	0.01
Fe (total)	mg/liter	0.04	0.01
HCO_3^-	mg/liter	55	-
Cl^-	mg/liter	20500	21350
F^-	mg/liter	3.85	1.92
SO_4^{2-}	mg/liter	3220	3080
TOC (Total Organic Carbon)	mg/liter	15	5
Total Alkalinity (p-value)	mg/liter	68	121
Turbidity	NTU	2~5	< 0.3
SDI (Silt Density Index)	(%/min)	> 6.7 (100% plugged) 20~25 (at 5min)	4~6 (at 15 min) 10~16 (at 5 min)
TDS (Total Dissolved Solids)	ppm	≈ 33,000	≈ 44,000
Bacteria	cells/ml	3,400	-
Algae	cells/ml	10^3~10^6	< 10~100

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4. 1 stage DMF performance ($FeCl_3$ dosing effects)

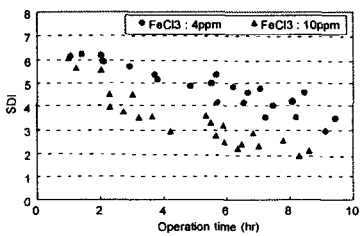
- The higher $FeCl_3$ dosing is, the lower SDI value is
- SDI value is lowered as operation time is increased.
- To achieve SDI < 3 within 2 hours with 1 stage, test condition like polymer dosing, DMF height increasing, finer anthracite application will be needed.

Test condition

Variable	unit	Value
$FeCl_3$	ppm	4 / 10
Anthracite Height	cm	55 (ES:1.1mm)
Sand Height	cm	45 (ES:0.35mm)
pH	-	6.5

(ES: Effective size)

SDI trends at 1 stage



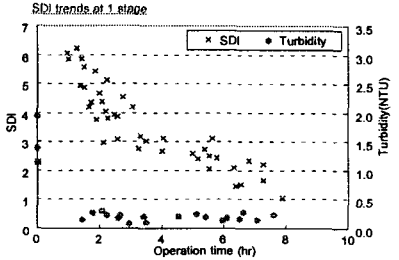
4. 1 stage DMF performance (with polymer dosing)

- With $FeCl_3$ and polymer dosing, SDI value is nearly lowered to 3 within 2 hours. Still, further more chemical dosing is needed to get enough performance.
- 2 stages DMF process will be better rather than chemical dosing increment.

Test condition

Variable	unit	Value
$FeCl_3$	ppm	10
Polymer	ppm	10
Anthracite (D:1.1mm)	cm	55~85 (ES:1.1mm)
Sand	cm	45 (ES:0.35mm)
Agitator	rpm	22
pH	-	6.5

SDI trends at 1 stage



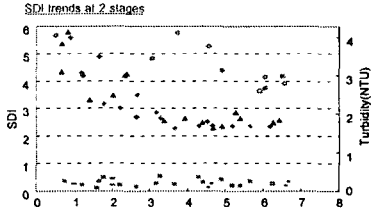
5. 2 stages DMF performance

- Seawater filtered at 1st stage DMF is filtered again at 2nd stage DMF.
- At 2 stages DMF, SDI value at 2nd stage outlet is lowered to nearly 3 within 2 hours.
- After SDI is lowered below 3, it tends to keep steady.
- Slightly low SDI value in case agitator is installed

Test condition

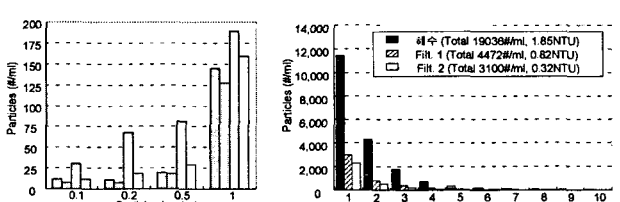
Variable	unit	Value
$FeCl_3$	ppm	24 (1st) 9 (2nd)
Polymer	ppm	0
Anthracite (D:1.1mm)	cm	55 ~ 85
Sand (D:0.35mm)	cm	65 ~ 95
Agitator	rpm	22
pH	-	6.5

SDI trends at 2 stages



6. Particles and Algae characteristics

- Larger particles than 1 micrometer in diameter are mainly distributed to around 1 micrometer.
- Sub-micron size particles have no trends here.



- Algae in filtered water are quite low comparing those in raw seawater.

Item	unit	Raw seawater	1st / 2nd filtered water	기타
편모조류 개수 (Eutreptiella gymnastica, Gonyaulax)	Cells / ml	1,400	20 / 0	Size range (㎛) : 30-60
Chl - a		0.074	0	

7. Conclusion

- Comparing to sea water quality in Middle East, that in Masan bay has high values of SDI, turbidity, TOC, algae, bacteria. These are caused to difficult pretreatment.
- Large chemical dosing at 1 stage DMF.
- Heightened DMF to have low SDI value.
- Lowered chemical consumption with 2 stages DMF process.
- Found quite few algae in filtered water.

8. On-gong works

- Case by case performance test varying seawater condition feed to DMF
- Optimum polymer dosing