FILMTEC Membranes

FILMTEC Elements Key to Success of Integrated Membrane-Based Reclamation System in Major Petrochemical Plant in Taiwan

Site Information

Location:
Taiwan

Purpose:
Reclaim wastewater to resolve water shortage problems during droughts

Time in Operation:
3 years

Performance:
Quality of reclaimed waste water higher than that of municipal water; plant operating well after 3 years

The use of FILMTEC™ membranes enabled China American Petrochemical Co., Ltd. to reclaim wastewater, resolving water shortage problems during droughts. (Photo courtesy of CAPCO)

Introduction

China American Petrochemical Co., Ltd. (CAPCO), located in Taiwan, is the largest purified terephthalic acid (PTA) producer in the world for a single site. The plant consumes approximately 40,000 m^3/d of fresh water for the manufacturing processes and utilities system. It also generates approximately 20,000 m^3/d of wastewater from the manufacturing processes, cooling tower blowdown, demineralizer regeneration, etc. The wastewater is discharged to a local wastewater treatment center for ocean discharge with the approval quota of 22,000 m^3/d.

Because the plant is located in a water-limited area with recurring seasonal droughts, water rationing during droughts has caused operational difficulties and production cutbacks. In addition, the total dissolved solids (TDS) concentration of the water supply has been increasing due to salt water intrusion to feed water sources, resulting in a shorter production cycle for the plant's ion-exchange-based water demineralization (DI) system. To solve the water shortage during droughts and prepare for future expansion, the plant conducted wastewater reclamation studies with an integrated membrane-based treatment system including ultrafiltration/reverse osmosis (UF/RO). After extensive pilot tests with 110 m^3/d capacity during July 1995 to August 1996, a commercial reclamation system with the capacity of 6,600 m^3/d of pure reclaimed water was commissioned in April 2000. This case history is a based on a technical presentation (1) reviewing three years of RO performance as a key process of the integrated membrane-based reclamation system. The RO system uses FILMTEC™ BW30-400 elements.

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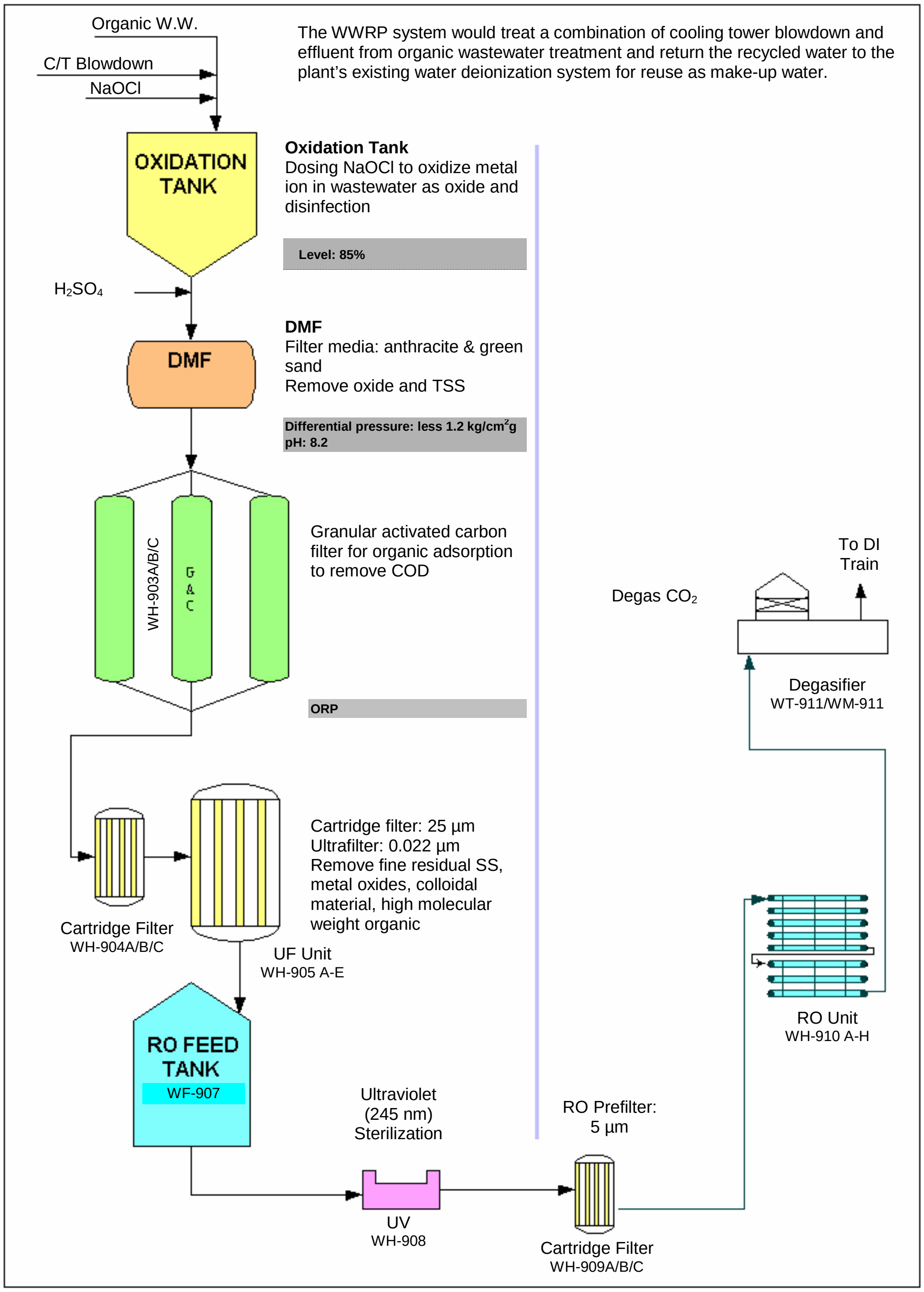
Final Process Design

The final process flow diagram is shown in Figure 1. The dual media filter (DMF) consists of three towers packed with green sand and anthracite coal as media with particle size of 0.55±0.5 mm and 1.1±0.05 mm, respectively. Flow rates were designed with 148 m^3/h/set.

The hollow fiber UF membrane (PM100, 6 inch x 48 inch, KOCH Membrane Systems) made of polysulfone has an anisotropic pore structure with nominal molecular weight cut-off of 100,000 Daltons. The UF system consists of five skids of 109 cartridges each with a total of 545 UF cartridges.

Figure 1. Final process flow diagram.



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Final Process Design, cont.

The UF system is operated at a recovery rate of 92%. The design flux (permeate) rate is 85.9 $L/m^2/h$ (50.6 gfd).The UF membrane cartridges are frequently cleaned by backwash and fast-flush of each skid of the cartridges with UF permeate water. A typical operation of backwash/fast-flush occurs every 60 minutes for 3.83 minutes. The sequence is executed by a programmable logic controller (PLC) automatically. The UV sterilizer was manufactured by WEDECO. The flow rate is 342.9 m^3/h. The influent quality is typically total coliforms (TC) less than 500 counts/100 mL, and the effluent quality is TC less than 50 counts/100 mL.

An RO train configuration was designed with two stages (five vessels for the first stage and three vessels for the second stage). Train capacity is 39 m^3/h with 80% recovery. The plant selected FILMTEC™ BW30-400 elements because of their high productivity and high removal capability for salt and organics. Based on the expected better water quality, especially silt density index (SDI), the averaged permeate flux was set at a relatively higher number of 22 $L/m^2/h$ (13 gfd). However, because of the high scaling potential of the feed water (silica, hardness, and bicarbonate), both acid and antiscalant dosing were recommended.

RO Plant Start-up

The entire reclamation unit started full operation in April 2000. The final water quality met the guarantee water quality in terms of Mn, Co, chemical oxygen demand (COD), and conductivity. Forty to fifty percent of COD was removed by the combination of DMF, granular activated carbon (GAC), and UF. However, still more than 50% of smaller molecule organics passed though the UF membrane. Since major COD components are estimated to consist of rather small molecular weight compounds, including *p*-xylene, benzoic acid, *p*-toluic acid, acetic acid, and terephthalic acid (TA), the rejection characteristics are reasonable. The RO process was proved to be essential to obtaining high-quality reclaimed water.

RO Plant Performance

In May 2001, the elements of five (B, E-H) out of eight trains were replaced with new elements because of a problem with chlorine oxidation, which has been corrected. Since then, the RO train has been operated with roughly 30 m^3/h capacity with two trains on stand-by mode. Operating pressure has been maintained around 10–13 kg/cm^2 compared to an estimated pressure of 18 kg/cm^2 for the designed capacity.

Figures 2 and 3 show the permeate conductivity changes. Figure 2 represents the overall combined product water quality, and Figure 3 shows the performance data for three of the trains operating with new elements (Trains B, E, and G). Because three trains (A, C, and D) are still operating with old elements, the overall conductivity is slightly higher compared to the trains with the new elements. However, overall product water quality has met the guarantee level of 240 µS/cm under the conditions of 3850 µS/cm feed conductivity for nearly three years.

Conductivity-based averaged rejection data are summarized in Figure 4 for three trains (B, E, and G) as an example. As can be seen, all elements have been kept in good condition, and no deterioration was observed after taking the corrective measures. Figure 5 shows the normalized permeate flow rates of three trains (B, E, and G). Initially permeate flow was reduced 10–15%. However, after this short time period, the normalized flow became quite stable and no further flow loss was observed.

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RO Plant Performance, cont.

Figure 2. Conductivity of RO feed and combined permeate from all trains from April 2001 to March 2003.

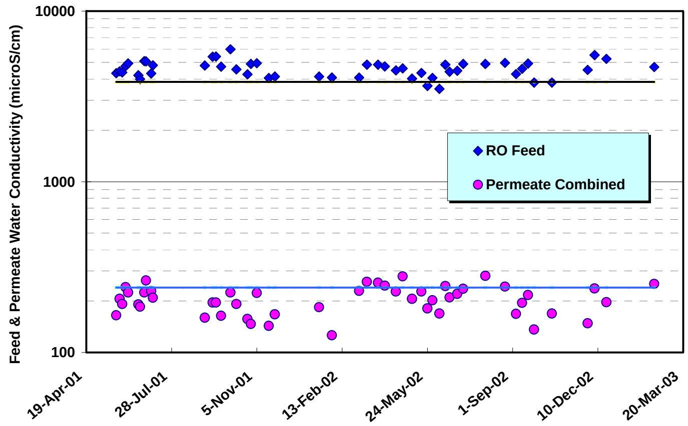


Figure 3. Conductivity of RO feed and permeate from three trains with new elements from April 2001 to March 2003.

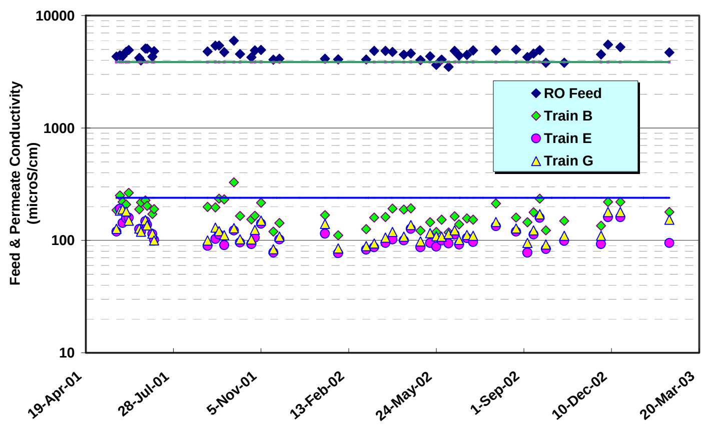
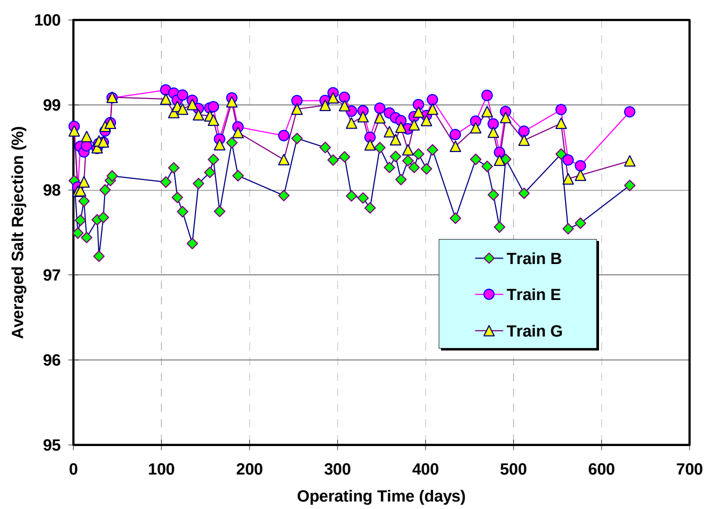


Figure 4. Averaged rejection data for three trains with new elements.



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RO Plant Performance, cont.

Figure 5. Normalized flow rates for three trains with new elements.

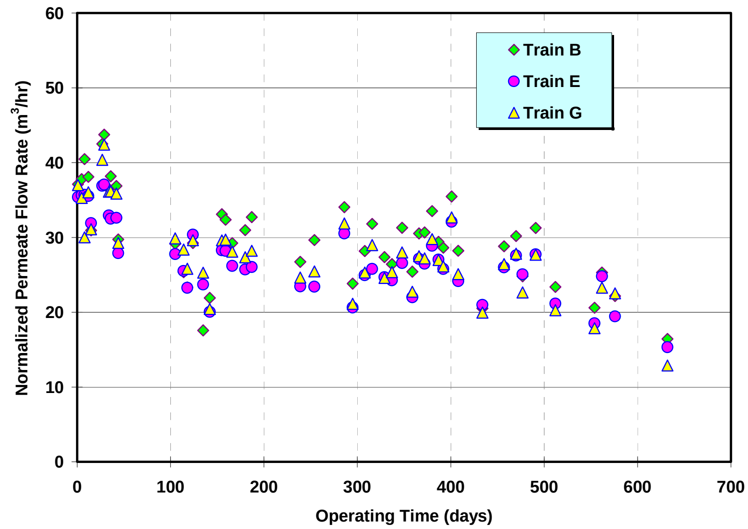
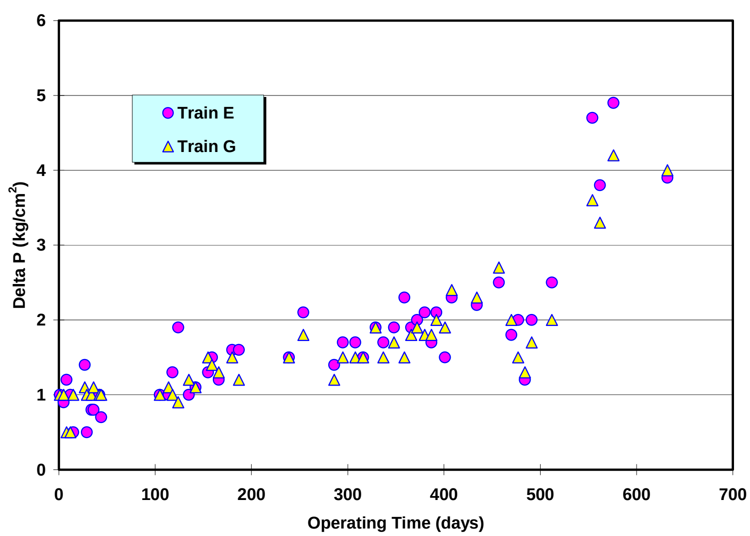


Figure 6 shows the actual differential pressure (delta p) across both stages (stage 1 and 2). During 2001-2002, the delta p increment was minimal when compared to a similar integrated membrane-based treatment facility in Chandler (2). The CAPCO RO plant performance was quite steady even though SDI was much higher than that (SDI < 1) of the Chandler plant. Therefore, any other factors such as TOC or COD and controlling biofouling might also be of importance in preventing fouling and/or scaling. However, at the end of November 2002, delta p suddenly increased to 4–5 kg/cm^2. This might be attributed to poor feed water quality and colloidal fouling with high SDI numbers. The plant identified high SDI numbers as the cause of damage to some UF cartridges. After replacing the elements in 2001, no cleaning in place (CIP) has been conducted at the RO plant. However, because of this situation, the plant decided to conduct CIP during February 2003 by using alkaline (4 Na-EDTA + NaOH) and acid (0.1% HCl) cleaning agents.

Figure 6. Delta p for two trains with new elements.



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Conclusions

Through extensive pilot tests, an RO pretreatment system was designed to be suitable for petrochemical wastewater characterized as high COD. Under the appropriate pretreatment, the thin-film composite RO membrane (BW30) had no flux decline and no rejection losses for nearly two years operation. Furthermore, the concept that an integrated membrane-based reclamation system (UF/RO) could remove impurities from the wastewater was proven. The reclaimed water quality is better than that of municipal water, resulting in extending the regeneration frequency of the ion exchange demineralizer system. Even though the plant initially encountered several difficulties, including scaling and membrane oxidation, after taking corrective measures, the plant could operate the system without any major problems.

Acknowledgments

Dow would like to acknowledge CAPCO project management manager, Mr. Larry C.C. Hu, as coauthor of the technical paper; CAPCO plant manager, Mr. C.C. Lin, and technical director, Mr. M.M. Yang, for their support in preparing this case study; and process engineer, Mr. M.H. Chang, for providing the data.

References

1. Larry C.C. Hu and Yasushi Maeda, “Integrated membrane-based reclamation system in a major petrochemical plant–3 years experience in Taiwan,” International Desalination Association (IDA) World Congress on Desalination and Water Reuse, Congress Proceedings, BAH03-083 (2003)
2. S. Freeman, George Harvey, and S. Taylor, “Using ultrafiltration to control high silt density index and turbidity as pretreatment for RO processing industrial wastewater,” Proceedings of 1998 North American Biennial Conference & Exposition, American Desalting Association, Williamsburg, Virginia, pp. 31 (1998)

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