DuPont™ Ultrafiltration

DuPont™ Ultrafiltration Modules Protect Reverse Osmosis System from High Iron

Site Information

Location:	ShanXi, China
Capacity:	2074 m^3/h (5283 gpm)
Purpose:	Pretreat waste water prior to RO system
Time in Operation:	Since August 2005
Performance:	Turbidity avg 0.05 NTU; SDI ≤ 3.0

Introduction

Taiyuan Steel Group Co. Ltd. has one of the largest stainless steel production capacities in the world. Major products include stainless steel, military steel, alloy molding steel, and electromagnetic pure iron. Taiyuan Steel planned to enlarge their stainless steel production capacity up to 0.5 million tons/year and needed to add a 2,700 tons/day water treatment plant to meet the demand for boiler make-up water for the power plant, cooling tower water, and clean recycle make-up water. To meet more stringent environmental protection requirements, Taiyuan Steel has built the largest reverse osmosis (RO) waste water treatment plant in China to recycle waste water for industrial purposes.

The raw water is a mixture of industrial waste water from the steel operation, containing high iron, high chemical oxygen demand (COD), and oil along with other contaminants. This complex mixture posed some challenges for the water treatment process. In particular, iron concentration could go as high as 12 ppm, and severe RO membrane fouling could occur if the water was not treated. Together with other advanced pretreatment equipment, DuPont™ Ultrafiltration modules are able to pretreat the waste water to meet the RO feed water requirements. A double floor design is used to save space. There are six ultrafiltration skids on each floor, giving a total capacity of 2074 m^3/h.

Two-floor arrangement of DuPont™ Ultrafiltration SFP-2860 modules in the Taiyuan facility. (Photo courtesy of Taiyuan Steel Group Co. Ltd.)

DuPont™ Ultrafiltration Modules

The SFP-2860 module is ideal for systems with capacities greater than 50 m^3/h (220 gpm). This 8-inch-diameter module offers a high effective membrane area, which contributes to a more economical membrane system design. At 60 inches long, the SFP-2860 module offers high efficiencies over a wide range of feed water conditions.

DuPont™ Ultrafiltration modules are made with high-strength, hollow-fiber membranes that have excellent features and benefits:

- 0.03 µm nominal pore diameter for removal of bacteria, viruses, and particulates (including colloids) to protect downstream processes such as reverse osmosis
- Polyvinylidene fluoride (PVDF) polymeric hollow fibers for high strength and chemical resistance that lead to long membrane life
- Hydrophilic PVDF fibers for easy cleaning and wettability that help maintain long-term performance
- Outside-in flow configuration for high tolerance to feed solids that helps reduce the need for pretreatment processes
- Unplasticized polyvinylchloride (U-PVC) housing that helps eliminate the need for costly pressure vessels

Water Treatment Process

Table 1 indicates the average raw water analysis. The raw water is a mixture of metallurgical waste water, rolled steel waste water, cooling tower blow down from Taiyuan Steel production lines, and some municipal waste water. Iron concentration could be as high as 12 ppm.

Table 1: Raw water analysis

Parameter	Unit	Value
Total hardness	ppm $CaCO_3$	1200
Total Fe	mg/L	6
Turbidity	NTU	30 to 40
Temperature	°C	10 to 35
Oil	mg/L	5 to 10
pH	–	7 to 8
SiO_2	mg/L	18
SO_4^{2-}	mg/L	540
Cl-	mg/L	280
Chemical oxygen demand (COD_{Cr})	mg/L	30 to 40
Alkalinity	–	130

Figure 1 is a diagram of the water treatment process. The aeration process converts Fe^{2+} to Fe^{3+}, enabling easier removal in later process steps. An addition of sodium hydroxide (NaOH) increases the rate of oxidization. Sodium hypochlorite (NaOCl) at a dosage of approximately 5 ppm is added depending on the feed water quality. Coagulants are added in the mechanical mixing basin (polyaluminum chloride [PAC] at 10–15 ppm and polyacrylamide [PAM] at 0.2–0.3 ppm), and floc is formed and settled in the clarifier for separation. Multimedia filters remove remaining floc and other suspended particles.

Residual sodium hypochlorite is neutralized with the addition of sodium bisulfite ($NaHSO_3$) dosed at 2–4 ppm. An antiscalant is added at a dosage of 4–5 ppm to prevent the RO membranes from scaling. Hydrochloric acid (HCl) at a dosage of 10–15 ppm is added with the antiscalant to adjust pH. A portion of the product water from the first-pass RO is used in the Taiyuan Steel production line, and the remaining is dosed with sodium hydroxide prior to the second-pass RO for pH adjustment. Mixed bed ion exchange polishes the RO water for boiler make-up supply.

Tables 2 and 3 provide the operating parameters for the ultrafiltration, reverse osmosis, and other unit operations. Table 4 further describes the ultrafiltration process.

Table 2: Operating parameters for ultrafiltration and reverse osmosis unit operations

Parameter	Unit	UF	1st RO	2nd RO
Component	–	SFP-2860	FilmTrec™ BW30-400-FR	FilmTrec™ BW30-400-FR
Capacity	m^3/h	2074	1400	300
Number of skids	–	12 (10:2)	7 (6:1)	2
Number of modules per skid	–	64	–	–
Total number of modules	–	768	–	–
Capacity per skid	m^3/h	189	235	150
Recovery	%	92	–	–
Flux	L/m^2h	40	–	–

Figure 1. Water treatment process

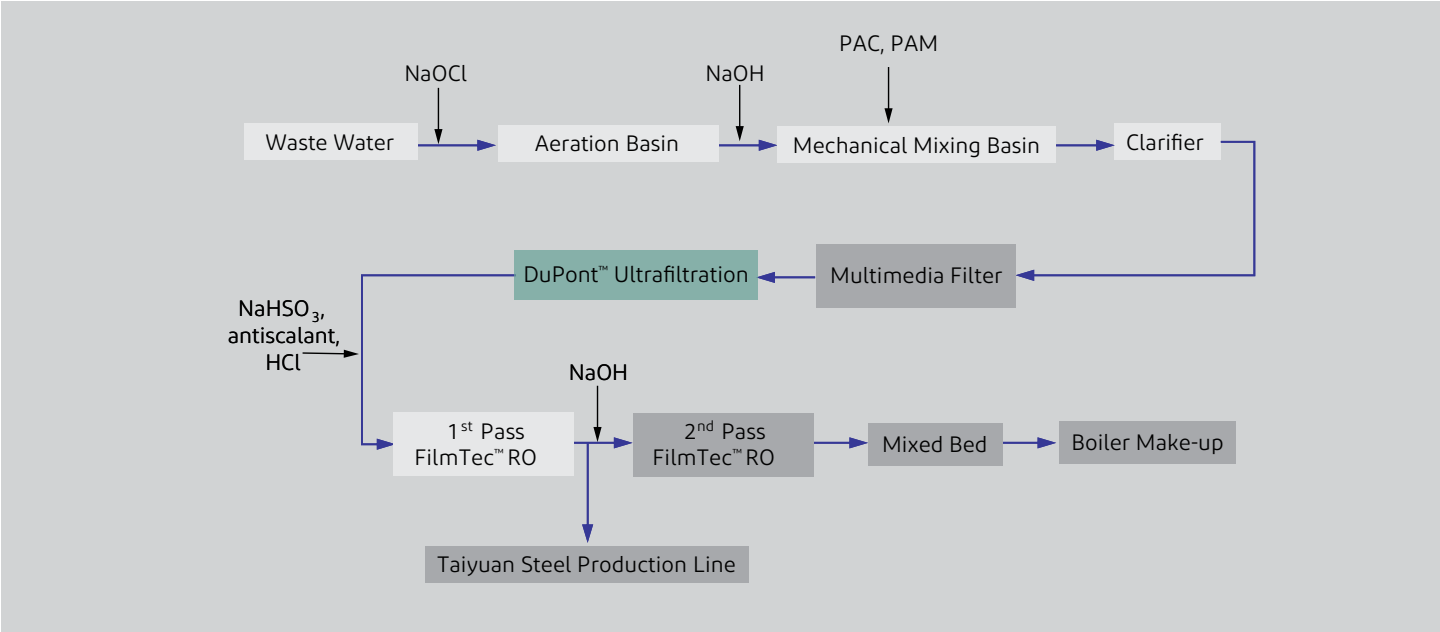


Table 3: Operating parameters for other unit operations.

Parameter	Unit	Clarifier	Multimedia Filter	Mixed Bed
Capacity	m^3/h	2474	2328	300
Number of skids	–	2	13 (12:1)	3 (2:1)
Capacity per skid	m^3/h	1237	194	150

Table 4: Ultrafiltration operating process.

Parameter	Frequency	Duration	Chemical Consumption
Filtration	–	55 min	–
Air Scour	Every 55 min	30 s	–
Backwash	Every 55 min	50 s	15 ppm NaOCl
Forward flush	Every 55 min	70 s	–
CEB[a]	None	None	–
CIP[b]	2–4 months	8 h	Alkaline: 0.05% NaOH, 0.2% NaOCl Acid: 0.36% HCl

[a]Chemically Enhanced Backwash
[b]Clean-in-Place

UF System Performance

Figure 2 shows the product water turbidity plotted against time. Turbidity is consistently around 0.05 NTU, demonstrating stable performance. Minor turbidity spikes are caused by system maintenance.

Figure 2. Product water turbidity versus time.

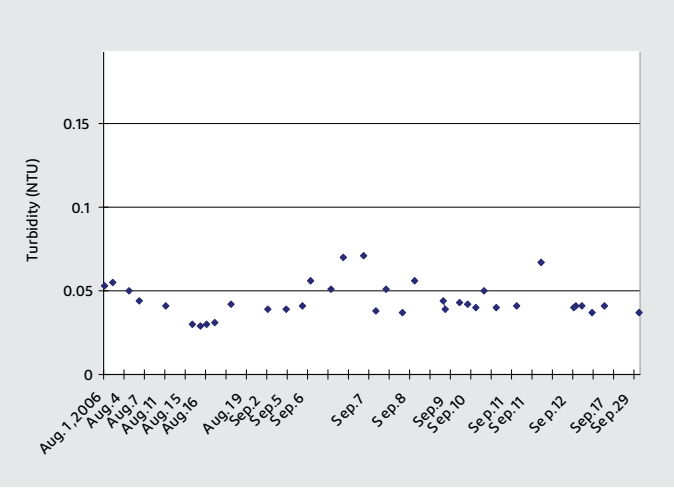
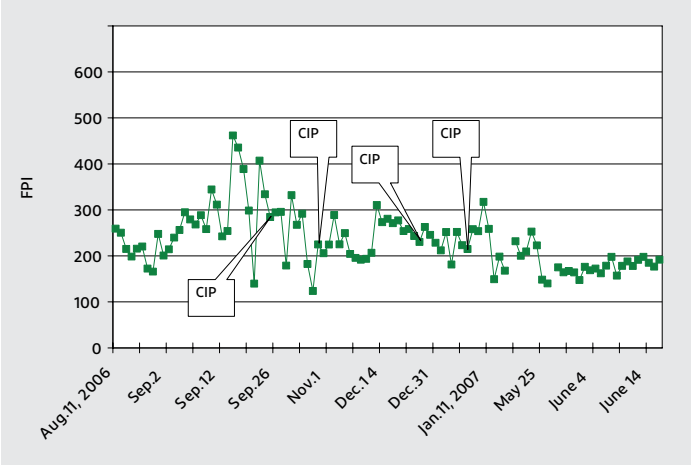


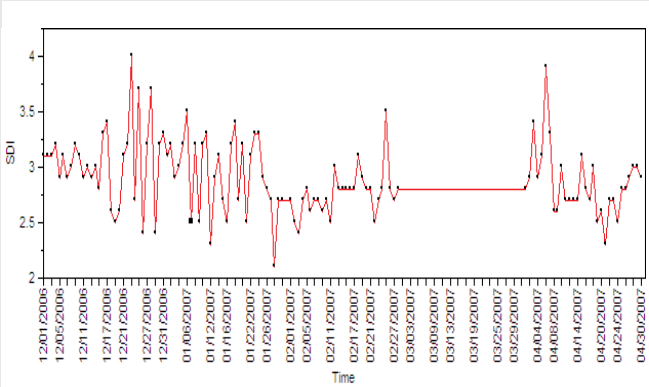
Figure 3 is a plot of the flow pressure index (FPI) vs time. FPI is calculated as the skid's permeate flow divided by transmembrane pressure (TMP). A constant FPI value indicates a good and stable UF operation performance. Due to the complexity of the feed water, more frequent CIP was required for proper UF membrane maintenance; however, the overall FPI remained stable over the period of time studied.

Figure 3. Flow pressure index versus time.



Despite the raw water challenge of high iron, COD, and oil, DuPont™ Ultrafiltration is able to maintain a stable and desired average SDI value of less than 3.0 (Figure 4). The stable permeate quality and the cleaning effectiveness demonstrate the ability of the UF system to withstand complex feed water without severe fouling.

Figure 4. Silt density index versus time.



Summary

Despite high iron levels and other contaminants in the feed water, Taiyuan Steel is able to reclaim their industrial waste water and produce acceptable RO feed water using DuPont™ Ultrafiltration membranes as part of the pretreatment system. The DuPont™ Ultrafiltration modules produce water with SDI less than 3.0 and average turbidity of 0.05 NTU.

High ultrafiltration product water quality enhances the performance of the RO system, resulting in optimal flux, salt rejection, and recovery. At half the footprint of a typical installation, Taiyuan's two-floor system comprising DuPont™ Ultrafiltration combined with FilmTec™ RO membranes provides an economical and successful solution for steel and metallurgical waste water treatment.

Have a question? Contact us at: dupont.com/water/contact-us

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