DOWEX™ UPCORE™ Mono Ion Exchange Resins
UPCORE System Boosts Production Efficiency of Refinery Process Water

Site Information
Location:
Poland
Size:
7 Lines at 240 m^3/h each
Purpose:
Improve process water quality and reduce chemical consumption
Comparative Performance:
- 60% reduction in chemical consumption
- 25% reduction in service water
- 80% reduction in waste water
- Greater than 50% reduction in Na and SiO_2 leakage
- Other improvements

At Polski Koncern Naftowy there are seven treatment lines for boiler feed water, all of which use the UPCORE™ system and DOWEX™ UPCORE Mono ion exchange resins. The photo above shows one of the lines with the cation bed in the foreground, then the weak base anion bed, and then the anionic layered bed. (Photo courtesy of Polski Koncern Naftowy Orlen)

Introduction

Polski Koncern Naftowy (PKN) processes crude oil into fuels, lubricants, base oils, bitumen, and other hydrocarbons and distributes these products throughout Poland. In 1993, PKN began a major upgrade and modernization of the complex at Plock, Poland. Their goal was to significantly improve efficiency and productivity to meet new European fuel quality standards.

The modernization plan included installation of a new boiler, which would require better quality process water. Requirements for this new water-treatment system included high efficiency and low consumption of chemicals. PKN was also looking for a system that would be reliable, simple to operate, and easy to automate with minimal downtime for maintenance. The company chose the UPCORE™ system and DOWEX™ UPCORE Mono resins.

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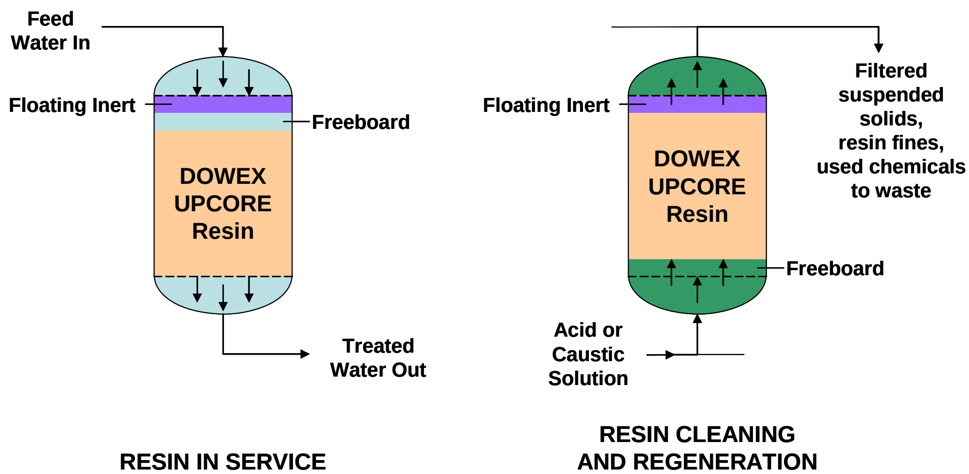
UPCORE™ System

The UPCORE™ system is based on the following principles:

- Counter-current ion exchange technology
- Packed bed design
- Upflow regeneration/downflow service
- Uniform particle size (UPS) resin technology

In the service cycle, a wide operational flow flexibility is possible. In this cycle, the feed water enters the vessel from the top (Figure 1). Before regeneration, compaction water flows at high velocity from the bottom to the top and compacts the resin bed against the inert resin and upper nozzle plate. Without flow interruption, the regenerant and subsequently the rinse water passes through the resin bed in an upflow direction. There is no need for a separate backwash tank because the suspended solids are automatically removed from the surface of the resin bed during the compaction step of each regeneration cycle.

Figure 1. The UPCORE system



The advantages to the UPCORE system include

- Excellent water quality
- High chemical efficiency
- Short regeneration time
- Simple construction and control
- Self cleaning
- Insensitivity to production flow variations and stops
- No risk of carry-over of resin fines
- Layered bed design without the need for a middle plate

The UPCORE system uses DOWEX™ UPCORE Mono ion exchange resins, which provide high operating capacity and chemical efficiency, reduced waste production, and outstanding mechanical integrity. These resins have high resistance to attrition, preventing generation of fines as the resins age in service.

Water Treatment Operation

The source for the process water at the Plock complex is the Vistula River, which is located near the refinery. Pretreatment of the river water includes dealkalization and filtration; treatment is demineralization. Tables 1 and 2 give the typical concentration of impurities in the feed water.

Table 1. Typical cation and anion levels in the feed water

Cations meq/L (ppm as $CaCO_3$)		Anions meq/L (ppm as $CaCO_3$)	
Calcium	2.7 (137)	Sulfates	1.7 (84)
Magnesium	1.0 (50)	Chlorides	2.6 (132)
Sodium	1.9 (94)	Nitrates	0
—	—	p value	0.7 (33)
—	—	m value	1.3 (66)
Total	5.6 (281)	Total	5.6 (281)

Table 2. Other impurities in the feed water

Component	Amount
Silica, mg/L as SiO_2	11.4
Organics, mg/L as $KMnO_4$	24
Total dissolved solids (TDS), meq/L	5–15 (range) 6–7 (typical)

Plant Design

There are seven lines, each with a flow of 240 m^3/h (1,057 gpm). The system cycles every 18 hours. Figure 2 shows a diagram of the system layout. Table 3 gives the mechanical details. Table 4 gives the process details.

Figure 2. Boiler feed water treatment system

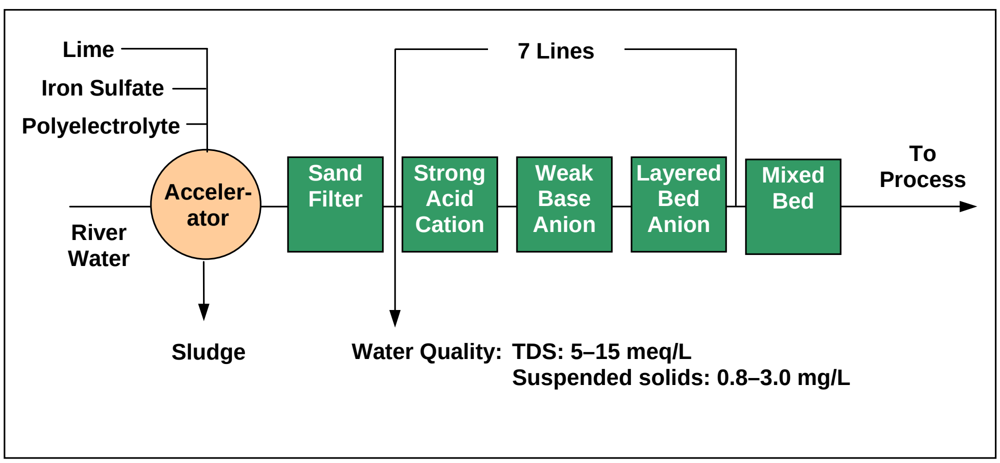


Table 3. Mechanical details of the UPCORE™ system

Parameter	Cation	Weak Base Anion	Anionic Layered Bed
Vessel diameter, m (ft)	3.0 (9.8)	3.0 (9.8)	3.0 (9.8)
Cylindrical height, m (ft)	3.5 (11.5)	3.0 (9.8)	3.0 (9.8)
Distribution system (top and bottom)	Nozzle plate		

Table 4. Process details of the UPCORE system

Parameter	Cation	Weak Base Anion	Anionic Layered Bed	
DOWEX™ UPCORE Mono resin	C-600	WB-500	WB-500	A-625
Volume, m^3 (ft^3)	22.8 (805)	14.7 (519)	8.3 (293)	7.6 (268)
Operating capacity, eq/L (kgr/ft^3 as $CaCO_3$)	1.18 (25.7)	1.0 (21.8)	1.0 (21.8)	0.5 (10.9)
Regenerant	HCl	NaOH		
Regeneration efficiency (% stoichiometry)	128	129		

Water Treatment Performance

The system began operating in 1998 and has been providing high-quality process water from the first run to the present. The excellent performance of the new treatment system is detailed in Tables 5 and 6.

Table 5. Performance improvements

Parameter	Before	After	Change
Demineralized water, m^3/yr (millions gal/yr)	6,254,600 (1,650)	6,254,600 (1,650)	—
Filtered water, m^3/yr (millions gal/yr)	9,019,133 (2,380)	6,792,496 (1,793)	–25%
HCl consumed (tons 100%/yr)	4,228	1,726	–59%
NaOH consumed (tons 100%/yr)	5,673	1,751	–59%
Waste water, m^3/yr (millions gal/yr)	2,764,533 (730)	537,896 (142)	–80%
TDS in waste water, tons/yr	8,297	2,744	–67%
TDS in filtered water, meq/L	8.2	6.6	–20%
Building surface	—	—	–50%
Manpower	—	—	–40%
Valves and piping	—	—	–50%

Table 6. Treated water quality

Parameter	After Anionic Layered Bed	After Mixed Bed
Conductivity, µS/cm	0.3–0.7	0.06–0.07
Silica, ppb SiO_2	5–10	3–5
Sodium, ppb Na	30–50	2–5

Conclusions

By installing the UPCORE™ system using DOWEX™ UPCORE Mono ion exchange resins, PKN realized significant process improvements over the former co-current flow technology, with 60% reduction in chemicals, 25% reduction in service water, and 80% reduction in waste. The company not only obtained high-quality process water that meets the goals of its modernization program, it significantly reduced overall operating and water costs. The process has been operating reliably since 1998.

DOWEX Ion Exchange Resins
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