Switch to an advanced ion exchange resin cuts boiler costs

A field study demonstrated how one refinery could save $384,000/yr by changing boiler feedwater ion exchange resin

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Constant deterioration of ion exchange resin, used to demineralize boiler feedwater, prompted Star Enterprise to conduct a side-by-side evaluation of two resins.

The study compared the macroporous weak base anion (WBA) resin that the refinery had used for years with a new WBA resin that features a uniform particle size.

The results of this field trial, which was conducted over an 18-month period, showed that the uniform particle size resin had a higher resistance to organic fouling and produced an average of 28 percent more treated water per cycle than the old resin. Replacement and regeneration costs with the new resin resulted in a $48,000 annual savings per bed of resin.

Background
The Port Arthur, Texas, refinery demineralizes surface water for use as boiler feedwater. Water, which is drawn from the Neches River, is supplied by the Lower Neches Valley Authority. The company's boilers produce an average of 1.6 million pounds of steam that is used to generate power and as process steam for the refinery and a nearby petrochemical plant. Minerals and other water-borne components of the water are relatively constant (Table 1).

Multiple-bed demineralizer systems that are supplied with water containing significant levels of dissolved solids, or that have a high potential for organic fouling of the strong base anion (SBA) resin bed, usually are operated with a weak base anion (WBA) resin ahead of the SBA resin (Figure 2).

A WBA resin placed ahead of a downstream SBA resin normally removes 80 percent to 90 percent of the organics that are common in surface waters. In addition, naturally occurring organics are removed more efficiently from WBA resin during regeneration than from an SBA resin. The high regeneration efficiency of WBA resin results in higher operating capacity and lower operating costs than can be achieved with an SBA resin operating alone.

Removal of organics during regeneration is not complete. Eventually, the WBA resin will accumulate organic contamination. As this fouling occurs, the throughput capacity of the WBA resin decreases and the rinse requirements increase. Therefore, a WBA

Table 1. Typical water analysis at the refinery.

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>18</td>
</tr>
<tr>
<td>Magnesium</td>
<td>18</td>
</tr>
<tr>
<td>Chloride</td>
<td>31</td>
</tr>
<tr>
<td>Sodium</td>
<td>33</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>13</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>46</td>
</tr>
</tbody>
</table>

Figure 1. There are eight trains in the Star Enterprise demineralizer system.
The refinery's demineralizer system consists of eight trains, each with a bed of strong acid cation resin followed by a bed of weak base anion resin and a final bed of strong base anion resin. The original WBA resin was a macroporous-type resin built on a styrene/divinylbenzene polymer matrix. Resin beads had a Gaussian particle size distribution with a median diameter of 650 microns. For greater regeneration economy, anion resins in the system are regenerated in a throughput fashion with sodium hydroxide; the used regenerant from the SBA resin is used to regenerate the WBA resin.

In the past, each demineralizer train was operated to a maximum throughput of 900,000 gallons before regeneration. Although the resin beds had a greater throughput capacity, previous studies on the system had shown that limiting the organic loading on the WBA resin extended resin life. The resin lasted from 18 to 24 months when the train was run to exhaustion, while resin life could be extended to 36 to 42 months when the train was regenerated after 900,000 gallons had been treated.

Even with this longer resin life, the need to replace WBA resin after 36 to 42 months of service because of organic loading led Star Enterprise to a trial of a relatively new type of WBA resin.

At the time the trial was held (1990 to 1992), the new resin was a developmental product of Dow Chemical Co. This resin has since been marketed and is now known as DOWEX® MARATHON® WBA resin.

Like the conventional WBA resin used at the refinery, the new resin is a macroporous type built on a styrene/divinylbenzene polymer matrix. The difference is that the newer resin has a smaller, more uniform particle size (UPS) with a nominal bead diameter of 400 microns and 85 percent of the beads are within ±150 microns of that value. The product offered greater throughput, higher regeneration efficiency, and the potential for higher resistance to organic fouling.

Conducting the field trial
Two identical demineralizer trains were set for the trial. One was loaded with new beds of the same resins being used in the other trains in the system and the other train used for the trial was loaded with the developmental WBA resin plus SBA and strong acid cation resins. The trial methodology called for quarterly analysis of the WBA resins for organic contamination and analysis of the effluent stream for total organic carbon removal.

In order to obtain comparative throughput data, both trains were to be operated to a WBA exhaustion limit of 20 micromhos/cm for four consecutive exhaustion/regeneration cycles per quarter. After the second series of capacity tests however, the methodology was changed so that both trains were operated to complete exhaustion for the remainder of the trial. The change was made primarily to challenge the UPS resin, which was predicted to have a superior ability to cast off organics during regeneration. If this proved to be true, the plant could extend run lengths and reduce regeneration and rinse expenses by operating the WBA resin to exhaustion rather than to a fixed throughput level.

As expected, both of the WBA resins accumulated organic fouling during the trial. The organic fouling was tracked by laboratory analysis of resin samples taken periodically from the operating beds. The rinse requirement of each resin was a further indication of organic fouling. After nine months of operation, the rinse requirement for the new UPS WBA resin increased from 10 gallons per cubic foot (gal/ft³) of resin to 133 gal/ft³. Rinse requirements for the conventional WBA resin rose from 35 gal/ft³ to 154 gal/ft³.

The dosage of caustic soda regenerant was increased to use excess caustic more efficiently in neutralizing sulfurous acid waste from the cation resin regeneration. This change in anion resin regenerant dosage reduced organic fouling on the UPS resin and cut the rinse requirement down to 50 to 60 gal/ft³ over the next six months.

The conventional WBA resin, on the other hand, exhibited no decrease in organic fouling in spite of the increased dosage of caustic. Its rinse requirement also continued to climb, reaching a level of 200 to 210 gal/ft³ during the same six months.

Over the last four months of the trial, feed water conductivity dropped, indicating lower levels of organic and dissolved mineral constituents. This change in operating parameters produced a corresponding increase in the throughput of the UPS WBA resin bed. The throughput of the conventional WBA bed, however, did not increase in response to the reduced loading during this time.

Experience showed that the conventional resin bed would have to be replaced within six to nine months after the end of the trial period. Because of the consistently high throughput per cycle for the UPS WBA resin, there was no basis for predicting a target date to replace the newer resin.

The UPS WBA resin required 18 fewer regenerations as a result of the greater throughput capacity that it demonstrated during this trial. This resulted in an annual savings in regeneration costs alone of more than $27,000. That produces a savings of $66 per year for every cubic foot of resin needed in the WBA bed.

AUTHORS

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