Forward osmosis as a part of water concepts in the mining industry

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Introduction

Good water quality is a prerequisite for effective enrichment and high yields in hydrometallurgical processes in the mining industry. Waste water also usually needs to be purified before discharge. However, large water volumes and targeting high removal of harmful compounds can cause strong economical hurdles for the water treatment.

Forward osmosis (FO) utilizing the osmotic pressure differences in streams of different concentration can be an attractive water reuse technology. High quality water can be energy efficiently extracted from flows which need to be concentrated. One potential water source is the neutralizing pond (NP) where the water is usually dilute enough to be used as feed solution.

Mines encompassing desalination based on reverse osmosis (RO) have readily available potential draw solutions such as sea water or desalination brine. When combining FO with RO, the feed for RO desalination is diluted with FO purified water. This decreases the total dry solid matter (TDS) of the feed to the RO plant, the operating pressure and the costs of pumping from the sea. A further advantage is the dilution of the brine, which from an environmental point of view facilitates brine discharge back to the sea. It is also possible to recycle the FO extracted water back to mining processes, when pregnant leaching solution (PLS) from bioleaching is used as a draw solution. Another potential draw solution in mining processes is nanofiltration concentrate from NP water, generated in required waste water treatment targeting sulphate removal.

In this study we compared the draw solution properties of sea water (SW), brine (SWB), brine from NP nanofiltration and pregnant leaching solution (PLS) to 2 M NaCl solution.

Properties of the solutions used in FO

FO feed solution was taken from a mine which is using bioleaching technology. Main components of the neutralizing pond water (NP) were sulphur, sodium, calcium and magnesium (Table 1). Draw solutions were standard sea water (SW), brine (SWB), nanofiltration concentrate of the neutralizing pond water, and pregnant leaching solution (PLS). The osmotic pressures of the solutions are shown in table 2.

Table 1. Main components and properties of neutralizing pond water used as feed solution in FO.

<table>
<thead>
<tr>
<th>Property</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Na</th>
<th>S</th>
<th>SO4</th>
<th>Osmotic pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>4 mS/cm</td>
<td>410 mg/l</td>
<td>285 mg/l</td>
<td>1.6 mg/l</td>
<td>15/10 mg/l</td>
<td>1720 mg/l</td>
<td>&gt; 2 bar</td>
</tr>
</tbody>
</table>

Table 2. The osmotic pressures of the draw solutions used in FO measured with Vapro Vapor Pressure Osmometer.

<table>
<thead>
<tr>
<th>Draw solution</th>
<th>2M NaCl</th>
<th>St sea water</th>
<th>St sea water</th>
<th>Brine of LO/Nu's PFS</th>
<th>PLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osm, bar</td>
<td>100</td>
<td>23</td>
<td>47</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Results and discussion

Brine from sea water RO (WR 50%) was as effective as draw solution as 2 M NaCl (Fig. 2). The fluxes were initially 12 l/m²h decreasing to 9 l/m²h due to the dilution of the draw solution during filtration. The flux with sea water was slightly lower, 7-8 l/m²h. At the same time precipitation of CaSO₄ occurred on the bottom of the feed tank (Fig 2).

In mines not equipped with desalination, PLS can act as a draw solution (pH > 2). Although generating a lower flux than seawater (50%), no further technique is needed for producing excellent quality water for e.g. bioleaching processes or flotation. PLS produced fluxes equal to the nanofiltration brine of neutralizing pond water.

Conclusions

Sea water and sea water brine worked well as draw solutions in FO. The greatest advantages could be received in lower energy costs both for concentration of mining streams and SWRO. Also PLS worked well as a draw solution. When PLS was used as a draw solution, RO quality of water was produced which can be recycled to the leaching process.

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