Optimizing Low-Grade Manganese Extraction
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Introduction
Manganese is predominately used in steel production.
The U.S. produces no manganese because sources are low-grade.
There is a need for low-grade manganese extraction.

Objective
- Optimize the acid leaching conditions of low-grade manganese sea-nodules using a 2^3 full factorial design of experiment.

Initial atomic manganese amount = 2.1%

Leaching Process
1 g oxalic acid was heated and stirred in 200 ml of 1.8 M sulfuric acid for 10 minutes.
The parameters were adjusted accordingly to each experiment and 10 g ground ore was added into the solution.
The solution was filtered and titrated.
The filtrate was diluted in 2% HNO₃ for analysis using atomic absorption machine.

Experimental
- The effects of stir rate, time, and particle size on manganese extraction were determined.
- The experiments were preformed again with added electricity, and compared to the original results.

Experimental Data

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Particle Size (µm)</th>
<th>Stir Rate (RPM)</th>
<th>Time (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>106 (-1)</td>
<td>300 (+1)</td>
<td>30 (-1)</td>
</tr>
<tr>
<td>2</td>
<td>106 (-1)</td>
<td>150 (-1)</td>
<td>30 (-1)</td>
</tr>
<tr>
<td>3</td>
<td>425 (+1)</td>
<td>300 (+1)</td>
<td>30 (-1)</td>
</tr>
<tr>
<td>4</td>
<td>425 (+1)</td>
<td>300 (+1)</td>
<td>120 (+1)</td>
</tr>
<tr>
<td>5</td>
<td>106 (-1)</td>
<td>300 (+1)</td>
<td>120 (+1)</td>
</tr>
<tr>
<td>6</td>
<td>425 (+1)</td>
<td>150 (-1)</td>
<td>30 (-1)</td>
</tr>
<tr>
<td>7</td>
<td>106 (-1)</td>
<td>150 (+1)</td>
<td>120 (+1)</td>
</tr>
<tr>
<td>8</td>
<td>425 (+1)</td>
<td>150 (+1)</td>
<td>120 (+1)</td>
</tr>
</tbody>
</table>

Recovery with electricity
Recovery without electricity

Parameter Effects
Without Electricity
- Size
- Stir Rate
- Time
- Size/Time
- Size/Rate

With Electricity
- Size
- Stir Rate
- Time
- Size/Time
- Size/Rate

Conclusion
- Increased stir rate, time and particle size gave the best results.
- Stir Rate and Time had biggest effect.

Future Work
- Optimize particle sizes
- Optimize recovery with a kinetic study
- Optimize time using more variation
- Optimize acid concentration

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