

Optimizing low-grade manganese carbonate extraction using sulfuric acid and oxalic acid

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Background

Manganese is mainly used as an alloying agent because as a pure metal it is too delicate. According to the Royal Society of Chemistry (2015), adding manganese steel raises the steel alloy's strength, workability and resistance to wear and tear, and manganese is usually mined in areas such as China, Africa, Australia and Gabon, with other sources including the ancient manganese nodules found along the Missouri River, which contain smaller amounts of manganese along with many other elements. These nodules contain less than 35 percent manganese, making them a low-grade manganese source. Low-grade extraction is too expensive for industrial consumers because of the total value of manganese recovered in relation to the cost.

Research objective

Currently, the United States has no domestic production of manganese because the only sources are low grade, resulting in \$1.2 billion of manganese being imported from other countries for domestic consumption, such as in the manufacture of cell batteries, plant fertilizers, animal feeds and steel (U.S. Geological Survey, 2015). This research was dedicated to finding out how to optimize the conditions for the acid leaching of low-grade manganese carbonate in acid solution using a 2³ full factorial design. The effects of parameters such as stir rate, time and particle size on the extraction of manganese was evaluated (Fig. 1). The experiments were run again with an added factor of electricity, and the results were compared against those of the original experiments to see if the manganese recovery was affected.

Results and conclusions

Stir rate and time together had the biggest effect, while increased stir rate, time interval and particle size gave the best results (Experiment 4, Fig. 2). Experiments 1-3 and 6 were run at the low limit time (-1) of 30 minutes. The reaction did not go to completion, but the recovery rates without electricity were almost always lower than the recovery rates with electricity. Experiments 4-5 and 7-8 were run for 120 mins (+1) and went to completion. With electricity, there was a decrease in total manganese recovery compared with without electricity. This presents the idea that there is a gap of time during a complete reaction where electricity creates an optimum condition for a certain time during the leaching process.

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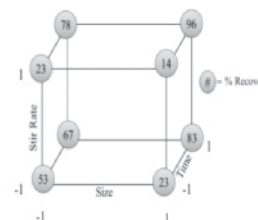


Figure 1 — x, y, z plot of the parameters.

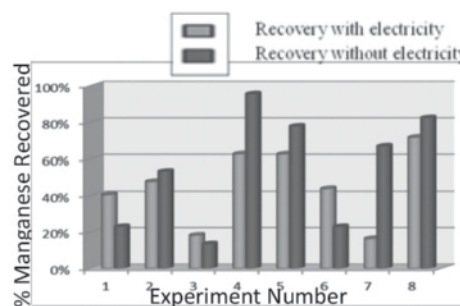


Figure 2 — Percent recoveries with and without electricity.

Experiment Number	Particle Size (µm)	Stir Rate (RPM)	Time (Min)
1	-106 (-1)	300 (+1)	30 (-1)
2	-106 (-1)	150 (-1)	30 (-1)
3	-425 (+1)	300 (+1)	30 (-1)
4	-425 (+1)	300 (+1)	120 (+1)
5	-106 (-1)	300 (+1)	120 (+1)
6	-425 (+1)	150 (-1)	30 (-1)
7	-106 (-1)	150 (-1)	120 (+1)
8	-425 (+1)	150 (-1)	120 (+1)

Figure 3 — Experiment number and parameters.