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Hydrometallurgical extraction of copper and cobalt from oxidised copper-cobalt ore using ammonia solution

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Abstract

Traditionally, copper and cobalt are extracted from oxidised ores via hydrometallurgical processing route. The ore is leached in sulphuric acid in reducing conditions. This method co-extracts impurity metal values like iron and manganese, necessitating downstream solution purification, which causes significant valuable losses. Pregnant leach solution purification is performed through step-wise oxidation and acid neutralisation of the leach solution. Cobalt is the most affected component in this process due to high losses incurred during the precipitation stages. Moreover, because the lixiviant is not recycled, the method consumes ominously high quantities of sulphuric acid. As a result, the process must be accompanied by readily available and cost-effective acid-making plant. In the event of an increase in the price of sulphuric acid raw materials or a decline in the ore grade, a source of 50% of the world's cobalt might be rendered impracticable.

This work investigates the viability of using ammoniacal solution as an alternative lixiviant to sulphuric acid. Ammoniacal solution forms soluble complexes with copper and cobalt at pH and potential where iron, manganese and other impurities tend to form precipitates. Because of the preferential leaching, downstream solution purification can be circumvented, thereby reducing valuable losses. Furthermore, because there is no solution altering, multi-step solution purification required, the leach solution retains its initial pre-leaching properties, making it fully recyclable. The recyclable nature of the lixiviant thus reduces lixiviant costs. Furthermore, an advantage of leaching in ammonia is lower equipment costs because ammonia is less corrosive than acid.

The feed material used in this study was an oxidised copper-cobalt ore sourced from Katanga Region in the DRC. A size fraction analysis was undertaken in order to determine the deportation of the copper and cobalt metals in the feed material. In the leaching tests conducted, the effect of particle size, temperature, concentration of the reducing agent and concentrations of ammonia and ammonium carbonate were investigated.

The results showed that a -75µm size fraction had the highest grade of copper and cobalt and was thus used for all the experiments undertaken. The results also indicated that cobalt and copper extraction was highly influenced by temperature. It was found that working at ambient temperature results in poor extraction of the value metal species while raising the temperature to 80°C significantly improves the extraction of both value metals if premature depressurising of the leach vessel is avoided.

The results also showed that there was no significant extraction advantage gained from milling finer than -63µm. Moreover, it was found that at 80°C, 2.0M ammonia solution, 0.4M ammonium carbonate, 300rpm, 0.4M reducing agent and 60 minutes pre-treatment and leach time, a peak extraction of 90% could be realised for copper. It was also noted that even better extraction efficiencies could be obtained for copper in the absence of a reducing agent. Optimum cobalt extraction of 85% was obtained at 80°C, 2.0M ammonia solution, 2.0M ammonium carbonate solution, 0.4M ammonium sulphite, 60 minutes pre-treatment time and

60 minutes leaching time. This compares well to about 40-60% recovery reported when leaching in acid.

These findings point to the conclusion that ammoniacal solution is a viable alternative to sulphuric acid for hydrometallurgical processing of the copper-cobalt ore.