THE LEACHING BEHAVIOUR OF A Ni-Cu-Co SULPHIDE ORE IN AN OXIDATIVE PRESSURE-ACID MEDIUM

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ABSTRACT

Hydrometallurgical processing of sulphide concentrates is an attractive method for the selective extraction of valuable metals. The dissolution of minerals in a leaching process involves several electrochemical parameters that need to be investigated to ensure the development and growth of the base metal industry in South Africa.

A study has been carried out to elucidate the leaching mechanism of a nickel-copper-cobalt sulphide concentrate in an oxidative pressure-acid medium. The sulphide concentrate studied in this research, comprises mainly of the minerals pyrrhotite, ($Fe_{1-x}S$) with x = 0 to 0.2, pentlandite, $(Ni,Fe)_9S_8$ and chalcopyrite, ($CuFeS_2$). The leaching behaviour of these minerals was successfully studied by means of Atomic Absorption (AA) measurements, Scanning Electron Microscopy (SEM) and Mössbauer spectroscopy, after leaching took place in an oxidative pressure-acid medium.

The dissolution of the valuable metals was achieved effectively with recoveries of well over 90% for nickel, copper and cobalt under the specific conditions studied. Mechanical activation by means of ultra fine milling improved metal extraction with an average of approximately 40%, after a leaching period of 150 minutes.

The most suitable conditions for the oxidative pressure-acid leaching of the mechanically treated nickel-copper-cobalt sulphide concentrate in a dilute sulphuric acid medium were found to be: particle size 80% - 10μm; temperature 110°C; oxygen partial pressure 10 bar; sulphuric acid concentration 30 kg/ton; solids content 15% by mass and an impeller agitation rate of 800 r/min. The values of the apparent activation energies of nickel, copper and cobalt, extracted from the sulphide concentrate, were found to be 20.6 (± 4.4) kJ/mol K, 33.6 (± 4.2) kJ/mol K and 17.4 (± 3.5) kJ/mol K respectively.

Keywords: *hydrometallurgy; pressure leaching; sulphide concentrate; pyrrhotite; pentlandite; chalcopyrite*

OPSOMMING

Hidrometallurgiese prosessering van sulfiederts is 'n aantreklike metode vir die selektiewe ekstraksie van waardevolle metale. Die oplossing van minerale in 'n loogproses omvat verskeie elektrochemiese parameters wat ondersoek moet word vir die versekering van die ontwikkeling en groei van die basiesemetaalindustrie in Suid Afrika.

'n Studie is onderneem om die loogmeganisme van 'n nikkel-koper-kobalt sulfiederts in 'n oksiderende druk-suur medium te identifiseer en te verklaar. Die sulfiederts wat ondersoek is, bestaan hoofsaaklik uit die minerale pirrotiet, ($Fe_{1-x}S$) met x = 0 tot 0.2, pentlandiet, $(Ni,Fe)_9S_8$ en chalkopiriet, ($CuFeS_2$). Die loogkarakteristieke kon suksesvol bestudeer word met behulp van, onder andere, Atoom Absorpsie (AA) metings, Skandeer Elektron Mikroskopie (SEM) en Mössbauer spektroskopie, nadat loging in 'n oksiderende druk-suur medium plaasgevind het.

Die oplossing van die waardevolle metale is effektief bereik met herwinnings van hoër as 90% vir nikkel, koper en kobalt onder die spesifieke toestande bestudeer. Meganiese aktivering deur middel van ultrafyn maling het metaalekstraksies verbeter met 'n gemiddeld van ongeveer 40% na 'n loog periode van 150 minute.

Die optimum toestande vir die oksiderende druk-suurloging van die meganies behandelde nikkel-koper-kobalt sulfiedkonsentraat in verdunde swaelsuur was: partikelgrootte 80% - 10µm; temperatuur 110°C; parsiële suurstofdruk 10 bar; swaelsuurkonsentrasie 30 kg/ton; massapersentasie soliedes 15% en 'n loopratroerspoed van 800 r/min. Die oënskynlike aktiveringsenergieë vir die metale nikkel, koper en kobalt, wat ge-ekstraheer is uit die sulfiedkonsentraat, was: 20.6 (± 4.4) kJ/mol K, 33.6 (± 4.2) kJ/mol K en 17.4 (± 3.5) kJ/mol K respektiewelik.

Sleutelwoorde: *hidrometallurgie; drukloging; sulfiedkonsentraat; pirrotiet; pentlandiet; chalkopiriet*

STATEMENT

I, Danie Strydom Smit, the undersigned, hereby declare that this dissertation, *The leaching behaviour of a Ni-Cu-Co sulphide ore in an oxidative pressure-acid medium,* is my own work.

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Co	cobalt
Cu	copper
Fe	iron
ΔG^{o}	gibbs free energy (J)
H	hyperfine magnetic interactions
IS	isomer shift
M	metal species
MS	metal sulphide species
Ni	nickel
O_2	oxygen
P	pressure (kPa)
P_{O_2}	oxygen partial pressure
QS	quadrupole splitting
R	ideal gas constant (8.314 J/mol K)
S	sulphur
t	time (seconds)
T	temperature (^{o}C)
UFM	ultra fine milling

Superscripts

-	negative charge
+	positive charge
57	atomic number of iron
®	registered trade name

Greek symbols

α	alpha
β	beta
δ	isomer shift
Δ	quadrupole interactions
ΔE	quadrupole splittings
γ	gamma
μ	micro