The Albion Process for Refractory Copper Concentrates

ALBION PROCESS

The Albion Process technology was developed by MIM Holdings (now Xstrata Plc) to treat concentrates produced from refractory base and precious metals ores. The process was developed in 1993 and has been patented worldwide.

The Albion Process incorporates the IsaMill horizontally stirred bead mill to produce an activated, finely ground concentrate at relatively low specific energy inputs. This finely ground mineral is then leached at atmospheric pressure in conventional agitated tanks. The capital costs of an Albion Process plant can be substantially lower than a comparable pressure or bacterial leach, due to the simplicity of the process flowsheet.

Figure 1: The M3000 IsaMill Installed at Lonmin, South Africa

The key to the Albion Process is the ultrafine grinding stage. The process of ultrafine grinding results in a high degree of strain being introduced into the mineral lattice. As a result, the number of grain boundary fractures and lattice defects in the minerals increases by several orders of magnitude, relative to unground minerals. The increase in the number of defects within the mineral lattice 'activates' the mineral, facilitating leaching. The rate of leaching is also enhanced, due to the dramatic increase in the mineral surface area.

Passivation of the mineral surface by sulphur based leaching products is also minimised by ultrafine grinding. Typically, precipitates that form on the surface of a leaching mineral will slowly passivate the mineral, by preventing the access of chemicals to the mineral surface. Passivation is normally complete once this precipitated layer is 2 – 3 microns thick. Ultrafine grinding of a mineral to a particle size of 80% passing 8 – 12 microns will eliminate passivation, as the leaching mineral will disintegrate prior to the precipitate layer becoming thick enough to passivate the mineral.

The oxidative leaching stage is carried out in non-pressurised agitated tanks. Oxygen is introduced to the leach slurry to assist oxidation. Leaching is carried out autothermally, in that the temperature of the leach slurry is set by the amount of heat released in the leaching reaction. Heat is not added to the leaching vessel from external sources. Temperature is controlled by the rate of addition of oxygen, and by the leach slurry density.

A general flowsheet for copper recovery from concentrates using the Albion Process is shown in Figure 2. Finely ground concentrate is leached in raffinate from the solvent extraction plant, which supplies acid and iron to the leach. Oxygen is injected into the leach tanks to facilitate leaching. The leach slurry density is adjusted to produce a copper grade in leach solution of between 20 and 40g/l, depending on the configuration of the solvent extraction plant.

The copper rich slurry is then neutralised with limestone slurry to control iron and acid ahead of the solvent extraction circuit. The neutralised slurry is then filtered to separate the oxidised residue, with the rich solution forwarded to solvent extraction. Conventional solvent extraction and electrowinning technology is used to produce copper cathode from the rich leach solution.

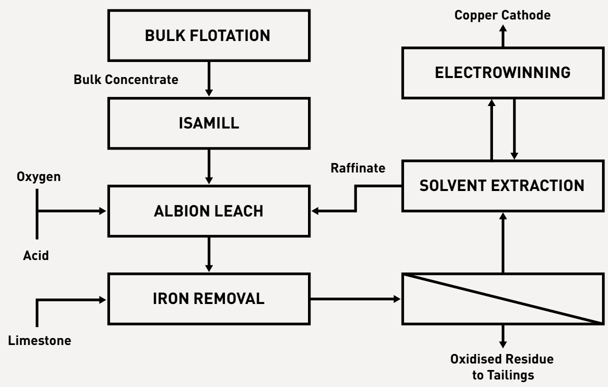

Figure 2: General Albion Process Flowsheet

The Albion Process is not sensitive to concentrate grade, and can process low grade and dirty concentrate that cannot traditionally be treated via smelting. The ability to treat a lower grade concentrate also allows for a higher recovery of copper in the flotation circuit, as well as a simpler float circuit design. The IsaMill can be placed within the flotation circuit to offer greater liberation and operating flexibility if required, or used to grind the final flotation concentrate.

Copper recoveries in the Albion Process leach circuit are typically in the range 97 – 99% w/w. The capital cost of the leach plant is low relative to both pressure and bacterial leaching, due to the simplicity of the leach circuit.

Process Chemistry

Chalcopyrite Leaching

The major refractory copper mineral present in most copper concentrates is chalcopyrite, and leaching occurs through oxidation by ferric iron. The general leach reaction in the Albion leach circuit for chalcopyrite is listed below. Typically, in excess of 90% of the sulphide sulphur in chalcopyrite will report to the leach residue as elemental sulphur.

$$CuFeS_2 + 2Fe_2(SO_4)_3 = CuSO_4 + 2S^o + 5FeSO_4$$

Chalcocite and Covellite Leaching

Other common copper minerals present in copper concentrates are chalcocite and covellite, and leaching again occurs through oxidation of these sulphides by ferric iron. The general leach reactions in the Albion leach circuit for chalcocite and covellite are listed below. Typically, in excess of 90% of the sulphide sulphur in chalcocite will report to the leach residue as elemental sulphur.

$Cu_2S + 2Fe_2(SO_4)_3 = 2CuSO_4 + 4FeSO_4 + S$

$CuS + Fe_2(SO_4)_3 = CuSO_4 + 2FeSO_4 + S$

Pyrite Leaching

Pyrite leaching will occur in the Albion leach circuit, however significant pyrite leaching will generally not occur until the majority of the copper minerals have been oxidised. The major pyrite leaching reaction is:

$FeS_2 + 7Fe_2(SO_4)_3 + 8H_2O = 15\ FeSO_4 + 8H_2SO_4$

Ferrous Iron Oxidation

The Albion leach is a ferric leach, with ferric iron continuously regenerated in solution by reaction with dissolved oxygen. The oxygen is supplied by the injection of oxygen gas into the slurry. The reaction for regeneration of ferrous iron is:

$2FeSO_4 + 1/2O_2 + H_2SO_4 = Fe_2(SO_4)_3 + H_2O$

Iron Control

In any acidic leach of copper concentrate, iron is released from iron bearing minerals such as chalcopyrite and pyrite. Iron is important to the leach process, as a source of ferric iron, however a control step is required to prevent excess iron building up in the recirculating leach solution. The preferred method of iron control in the Albion Process is goethite precipitation. The discharge temperature from the Albion leach is typically in the range 80 – 90 degrees, which is ideal for goethite precipitation. The leach discharge slurry is neutralised with limestone to a pH in the range 2.5 – 3, with the residence time in the goethite circuit adjusted so that the background ferric level in a continuously fed circuit is less than 1g/l. Copper losses to the goethite precipitate will be in the range 1 – 3%, however can be reduced substantially with proper configuration of the goethite circuit. Settling and filtration rates for the goethite precipitate are usually excellent. The goethite circuit is operated with a 300 - 600% recycle of thickener goethite product to the head of the circuit to act as seed and reduce limestone consumption.

Iron levels in the solution following iron removal are typically maintained in the range 8 – 20g/l, depending on the mineralogy of the concentrate to be leached. This soluble iron is recycled to the leach in solvent extraction raffinate, to provide an iron source to the leach circuit.

The goethite product is thickened, with the thickener underflow filtered. Combined filtrate/thickener overflow and filter washings then report to the solvent extraction circuit for copper recovery.

The main iron precipitation reaction in the goethite stage is:

$Fe_2(SO_4)_3 + 3CaO + 7H_2O = 2FeO.OH + 3CaSO_4.2H_2O$

Where arsenic is present in the concentrate, it will generally be fixed in the leach residue as ferric arsenate, which forms in the goethite stage via the reactions:

$HAsO_2 + Fe_2(SO_4)_3(a) + 2H_2O = H_3AsO_4 + 2FeSO_4(a) + H_2SO_4$

$Fe_2(SO_4)_3 + 2H_3AsO_4 + 3CaO = 2FeAsO_4 + 3CaSO_4.2H_2O + H_2O$

Precious Metal Recovery from the Leach Residue

Precious metals recovery from the goethite residue can be achieved by conventional cyanidation. The gold recovery will depend on the level of oxidation of the main gold carriers in oxidative leach, which are typically chalcopyrite and pyrite.

Solvent Extraction/Electrowinning

Following the goethite stage, the neutralised solution is generally processed via solvent extraction and electrowinning to recover copper as cathode. The target copper tenor in leach solution from the Albion Process will depend on the configuration of the solvent extraction circuit, and the strength of the organic employed, however will typically be in the range 20 – 40g/l.

A three stage extraction circuit operating an O/A ratio of 1.8:1 is typically employed to treat the leach solution, with a raffinate tenor of 0.8g/l. Organic strengths of 25 – 30% are used. Reagents such as LIX 622, LIX 973 and Acorga M5640 have been successfully tested in pilot plant operations. The acid credit from the solvent extraction circuit is returned to the leach, as raffinate is used to re-slurry the ground concentrate and dilute the feed concentrate slurry to the preferred leach slurry density.

Copper is stripped off the loaded organic and recovered in a copper electrowinning tankhouse. Xstrata Technologies market the Isa Process copper electrowinning technology, which is used worldwide for the production of copper from leach plants.

Process Water Balance

The circuit water balance is maintained by bleeding solvent extraction raffinate or filter cake washings or a combination of both. The bleed may either be neutralised in a two stage process, with copper bearing neutralised solids returned to the head of the leach circuit for copper recovery, or processed in a secondary solvent extraction circuit to recover copper prior to neutralisation of the secondary solvent extraction raffinate.

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