The Albion Process for Mixed Zinc/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 concentrate 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.

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

The key to the Albion Process is the ultra fine grinding stage, resulting in a high degree of strain being introduced into the mineral lattice. The number of grain boundary fractures and lattice defects in the minerals increases by several orders of magnitude, relative to unground minerals. This 'activates' the mineral, facilitating leaching. The increase in the mineral surface area also enhances the leaching rate. Passivation of the mineral surface by sulphur based leaching products is minimised by ultrafine grinding. 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. 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.

Oxidative leaching is carried out in non-pressurised agitated tanks by introducing oxygen to the leach slurry. Leaching is carried out auto-thermally, the temperature of the leach slurry is set by the amount of heat released in the leaching reaction. Temperature is controlled by the rate of addition of oxygen, and by the leach slurry density. Two general flowsheets for zinc and copper recovery from concentrates using the Albion Process are shown in Figures 2 and 3. The method chosen depends on the proportions of copper and zinc in the concentrate.

For concentrates that are high in zinc, the first flowsheet, shown in Figure 2, is used. Finely ground concentrate is leached in spent electrolyte from the electrowinning cell house. Zinc, copper, and iron are leached from the concentrate. The slurry is then neutralised to control iron and acid. Copper is removed from the neutralised solution by either solvent extraction or precipitation techniques, with the treated solution advanced to a conventional zinc dust purification and electrowinning cellhouse.

The neutralisation stage can be in the form of a conventional neutral leach, with the Albion leach slurry neutralised by contacting with calcine. In this method, neutral leach residue is then thickened and recycled to the Albion leach circuit to recovery zinc from ferrites. This method would generally be employed where the Albion leach is an expansion to an existing operation.

In the absence of a roaster, the neutralisation may be carried out by the use of basic zinc sulphate, produced in the bleed treatment circuit. This neutralisation is a two-stage process, with residue from the second neutralisation stage recycled to the leach to minimise zinc losses. The copper removal circuit can consist of a conventional solvent extraction circuit, to selectively extract copper from the zinc rich liquor, or alternatively copper can be selectively precipitated as a sulphide.

For concentrates that are high in copper and low in zinc, the second Method, shown in Figure 3, is used. Finely ground concentrate is leached in raffinate from the solvent extraction plant, which supplies acid and iron to the leach. Copper and zinc are recovered to the leach solution.

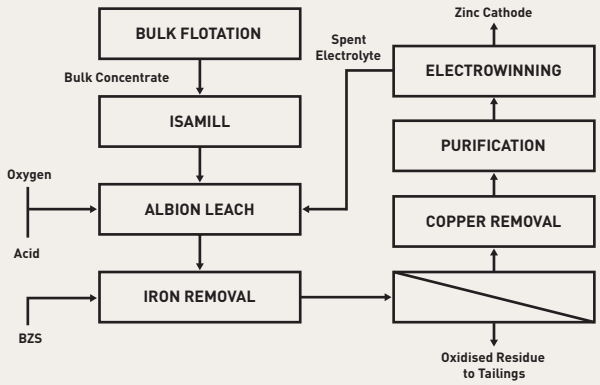

Figure 2: Albion Process Flowsheet for Treating High Zinc/ Low Copper Concentrates

The slurry is then be neutralised with limestone slurry to control iron and acid and filtered to separate the oxidised residue, with the rich solution forwarded to zinc removal. Zinc is then removed from the neutralised liquor by solvent extraction or selective precipitation. The liquor is then advanced to the copper solvent extraction circuit.

Conventional solvent extraction and electrowinning technology are used to produce copper cathode from the rich leach solution.

The Albion Process is not sensitive to concentrate grade, and can process low grade, dirty concentrates, high in iron, copper, and lead, that cannot traditionally be treated via roasting. The ability to treat a lower grade concentrate also allows for a higher recovery of zinc and 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.

Zinc and 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 lower due to the simplicity of the leach circuit.

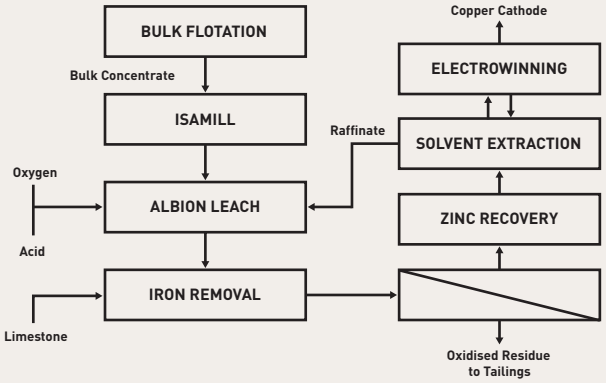

Figure 3: Albion Process Flowsheet for Treating High Copper/ Low Zinc Concentrates

Process Chemistry

Sphalerite Leaching

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

$$ZnS + Fe_2(SO_4)_3 = ZnSO_4 + 2FeSO_4 + S$$

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 zinc 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 zinc concentrate, iron is released from iron bearing minerals such as ferrites and pyrite. Iron is also often present in solid solution within the sphalerite matrix. 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 will depend on the type of circuit employed. Where the Albion leach is used in conjunction with an existing roast/leach plant, then the majority of the iron will be removed in a jarosite stage, with any remaining iron removed in the neutral leach. The main iron precipitation reaction in the jarosite stage is:

$$3Fe_2(SO_4)_3 + Na_2SO_4 + 12H_2O = 2NaFe_3(SO_4)_2(OH)_6 + 6H_2SO_4$$

Where the Albion leach is used in a stand alone application, the preferred method of iron removal is by 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 basic zinc sulphate to a pH in the range 4 – 4.5, 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. Zinc losses to the goethite precipitate will be in the range 1 - 3%, however they 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.

The main iron precipitation reaction in the goethite stage is:

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

The basic zinc sulphate used in the goethite stage is generated in the bleed treatment plant, where zinc rich liquor is neutralised to provide a water bleed for the circuit. Iron levels in the solution following iron removal are typically maintained in the range 8 – 10ppm.The neutralised leach slurry is thickened, with the thickener underflow filtered. Combined filtrate/ thickener overflow and filter washings then report to the zinc dust purification plant ahead of zinc electrowinning.

Process Water Balance

The circuit water balance is maintained by bleeding leach solution or filter cake washings or a combination of both. The bleed is neutralised with limestone to form basic zinc sulphate, which is returned to the plant for neutralisation duties.

For more information regarding the Albion Process, please contact:

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