ALBION PROCESS™

SIMPLICITY IN LEACHING

THE ALBION PROCESS FOR COPPER/ZINC CONCENTRATES

ALBION PROCESS™

xstrata technology

1 General Albion Process™ Description

The Albion Process™ is a combination of ultrafine grinding and oxidative leaching at atmospheric pressure. The feed to the Albion Process™ is a concentrate containing base or precious metals, and the Albion Process™ is used to oxidise the sulphide minerals in the concentrate and liberate these metals for recovery by conventional means.

The Albion Process™ technology was developed in 1994 by Xstrata PLC and is patented worldwide. There are three Albion Process™ plants currently in operation. Two plants treat a zinc sulphide concentrate and are located in Spain (4,000 tpa zinc metal) and Germany (18,000 tpa zinc metal). A third Albion Process™ plant is operating in the Dominican Republic treating a refractory gold/silver concentrate, producing 80,000 ounces of gold annually. A photograph of the Las Lagunas IsaMill™ and oxidative leaching circuit is shown in Figure 1. Xstrata Technology is currently completing the design and supply of an Albion Process™ plant for the GPM Gold Project in Armenia. Procurement has begun for this project, with civil works on site advanced. The GPM Gold Project will commission in September, 2013.

Figure 1
Las Lagunas Albion Plant

The first stage of the Albion Process™ is fine grinding of the concentrate. Most sulphide minerals cannot be leached under normal atmospheric pressure conditions. The process of ultrafine grinding results in a high degree of strain being introduced into the sulphide mineral lattice. As a result, the number of grain boundary fractures and lattice defects in the mineral increases by several orders of magnitude, relative to un-ground minerals. The introduction of strain lowers the activation energy for the oxidation of the sulphides, and enables leaching under atmospheric conditions. The rate of leaching is also enhanced, due to the increased mineral surface area.

Fine grinding also prevents passivation of the leaching mineral by products of the leach reaction. Passivation occurs when leach products, such as iron oxides and elemental sulphur, precipitate on the surface of the leaching mineral. These precipitates passivate the mineral by preventing the access of chemicals to the mineral surface.

Passivation is normally complete once the precipitated layer is 2 – 3 µm thick. Ultrafine grinding of a mineral to a particle size of 80% passing 10 – 12 µm will prevent passivation, as the leaching mineral will disintegrate prior to the precipitate layer becoming thick enough to passivate the mineral. This is illustrated in Figure 2.

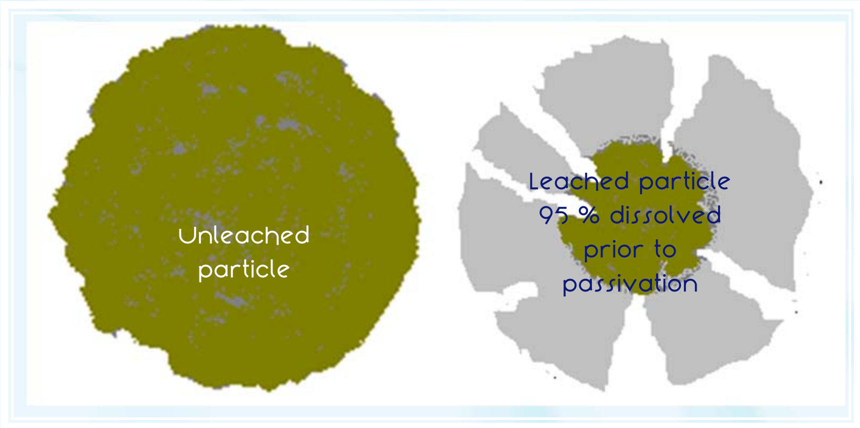


Figure 2
Mechanism of Passivation of Sulphide Minerals

After the concentrate has been finely ground, the slurry is then leached in agitated vessels, and oxygen is introduced to the leach slurry to oxidise the sulphide minerals. The agitated leaching vessels are designed by Xstrata and are known as the Albion Leach Reactor. The Albion Leach Reactor is agitated using dual hydrofoil impellers and oxygen is introduced to the leach slurry at supersonic velocity to improve mass transfer efficiency and ensure efficient oxidation of the sulphides. The Albion Leach Reactor is designed to operate at close to the boiling point of the slurry, and no cooling is required. Leaching is carried out autothermally, and the temperature of the leach slurry is set by the amount of heat released by the leaching reaction. Heat is not added to the leaching vessel from external sources, and excess heat generated from the oxidation process is removed through humidification of the vessel off gases.

2 Ultrafine Grinding and the IsaMill™ Technology

Ultrafine grinding requires a different milling action than found in a conventional ball mill, due to the fine nature of the grinding media required. In most ultrafine grinding mills, an impeller is used to impart momentum to the media charge. Media is agitated through stirring, and the resulting turbulent mixing overcomes the tendency of fine media to centrifuge. Abrasion is the major breakage mechanism in a stirred mill. The common aspects of a stirred mill are a central shaft and a series of impellers attached to the shaft. These impellers can be pins, spirals, or discs.
In stirred mills, two configurations are common. In the first, the mill shaft and grinding elements are set up vertically within the mill. This type of configuration is limited in size to typically 750 kW of installed power or less. This limitation is brought about by the large break out torque imposed on the impeller located at the base of the media charge, due to the compressive load of media sitting vertically on the impeller.

In the second configuration the mill shaft is aligned horizontally within the mill chamber. This configuration, which is used in Xstrata's IsaMill™, is more cost efficient at motor sizes in excess of 500 kW. There is very little break out torque required to begin to agitate the media charge, which limits the motor size to that required for grinding only.

The IsaMill™ is a large-scale energy efficient continuous grinding technology specifically developed for rugged metalliferrous applications. Xstrata supplies the IsaMill™ technology to mining operations around the world, with over 100 mills installed in 9 countries worldwide. The IsaMill™ uses a very high energy intensity of 300kW/m^3 in the grinding chamber, resulting in a small footprint and simple installation. The IsaMill™ can be scaled up directly from small scale laboratory tests. Xstrata's IsaMill™, is installed in more than two-thirds of the world's metalliferrous ultrafine grinding applications. The grinding media size for the IsaMill™ is within the size range 1.5 – 3.5 mm. Media can come from various sources, such as an autogenous media screened from the feed ore, silica sands or ceramic beads.

Xstrata will provide the IsaMill™ as a packaged Grinding Plant, consisting of the mill, slurry feed and discharge systems, media handling system, all instrumentation and control and all structural steel and platforms. Some of the IsaMill™ Grinding Plant components are shown in Figure 3 and 4. The IsaMill™ Grinding Plant incorporates all of Xstrata's operational and design experience gained from over 100 IsaMill™ installations, ensuring a trouble free commissioning.

The IsaMill™ will contain up to eight discs on the shaft, with each disc acting as a separate grinding element. The operating mechanism for the IsaMill™ is shown in Figure 5. This allows the IsaMill™ to be operated in open circuit without the need for cyclones. The IsaMill™ produces a sharp size distribution in open circuit, as the feed must pass through multiple distinct grinding zones in series before reaching the Product Separator. This plug flow action ensures no short circuiting, and efficiently directs energy to the coarser feed particles.

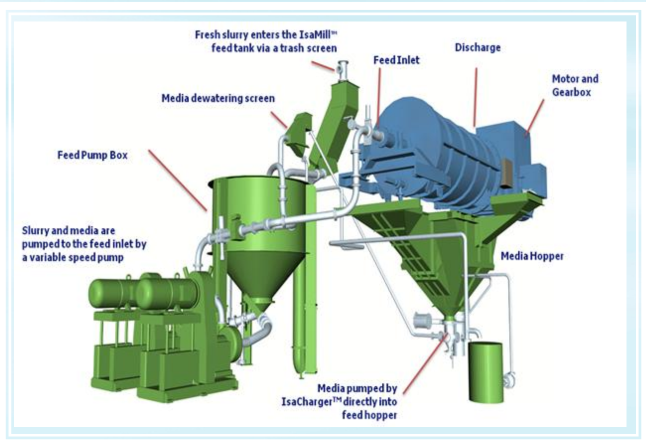


Figure 3
IsaMill™ Feed and Media Systems

The Product Separator is a centrifugal separator at the end of the mill shaft that spins at sufficient rpm to generate over 20 "g" forces, and this action is responsible for the sharp classification within the mill. The IsaMill™ can be operated in open circuit at high slurry density, which is a key advantage for the leaching circuit, as the entry of water to the leach is limited, simplifying the water balance.

The IsaMill™ uses inert grinding media that produces clean, polished mineral surfaces resulting in improved leaching kinetics. A steep particle size distribution is produced in the mill. The 98 % passing size in the mill is typically less than 2.5 times the 80 % passing size, and very little coarse material enters the leaching circuit, resulting in very high leach recoveries.

The IsaMill™ is the highest intensity grinding technology available (>300kW/m^3), meaning it is also the most compact, with a small footprint and low profile. The IsaMill™ is oriented horizontally, with the grinding plant accessed by a single platform at an elevation of approximately 3 m. Access to the mill and maintenance is simplified by the low operating aspect of the IsaMill™ and the associated grinding plant. Maintenance of the IsaMill™ is similar to routine maintenance for a slurry pump.

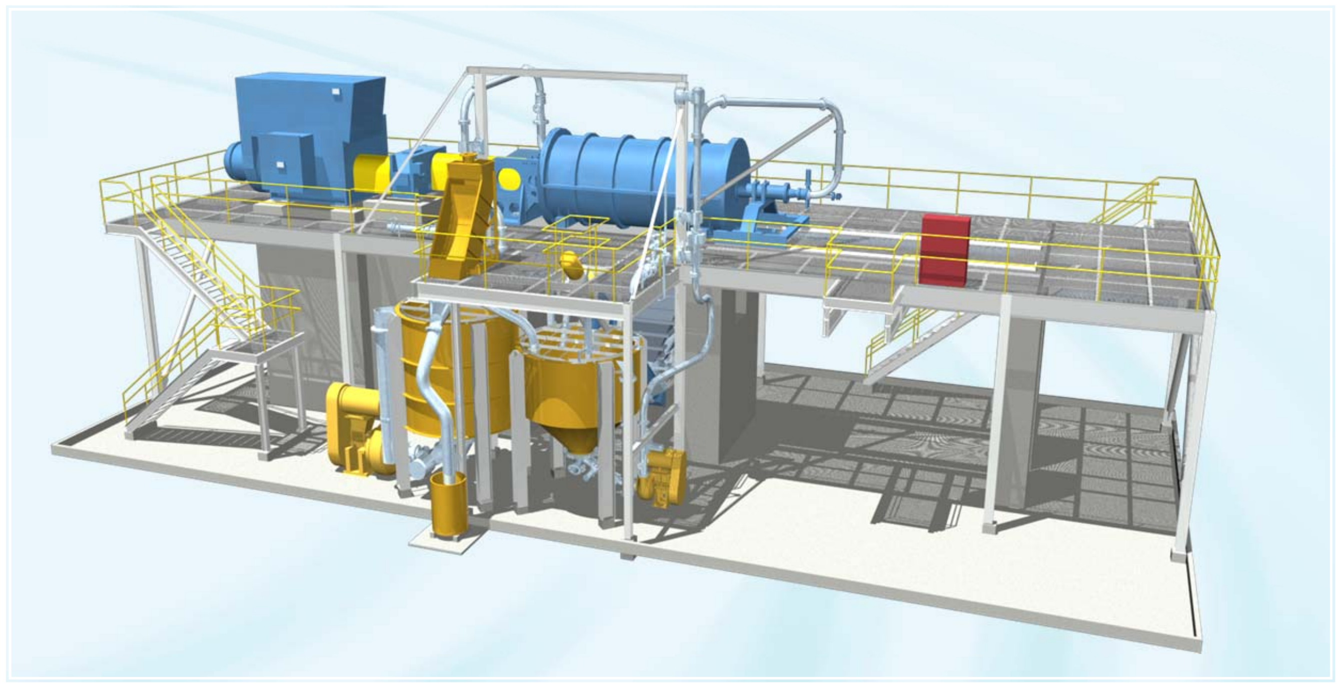


Figure 4
IsaMill™ Grinding Plant Layout

The internal rotating shaft in the IsaMill™ is counter-levered at the feed inlet end so the discharge end flange and grinding chamber can be simply unbolted and slid off using hydraulic rams. A shut down for inspection and replacement of internal wear parts takes less than 8 hours. Availability of 99% and utilisation of 96% are typical of the IsaMill™.

Scale-up of the IsaMill™ is straight forward. Laboratory test results are directly scaled to commercial size with 100% accuracy. The IsaMill™ has a proven 1:1 direct scale-up to reduce project risk.

The IsaMill™ is available in the following models:

- M500 (300 kW), capable of throughputs in the range 2 – 6 tonnes per hour
- M1000 (500 kW), capable of throughputs in the range 10 – 16 tonnes per hour
- M5000 (1200 and 1500kW), capable of throughputs in the range 20 – 60 tonnes per hour
- M10000 (3000kW), capable of throughputs in the range 60 – 100 tonnes per hour

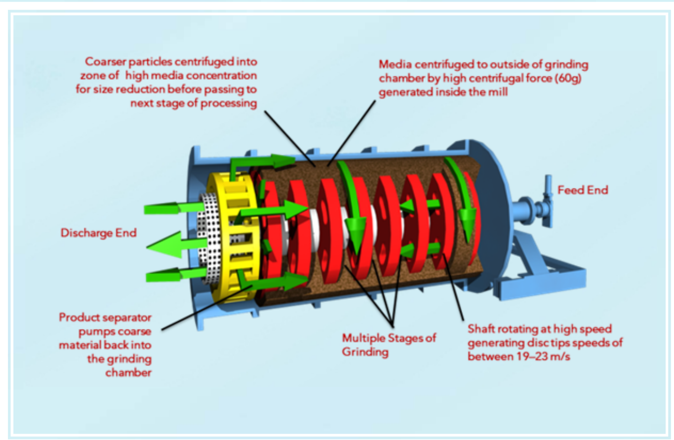


Figure 5
IsaMill™ Operating Mechanism

3 Oxidative Leaching

After the sulphide concentrate has been finely ground, it is then leached under atmospheric conditions in an oxidative leach consisting of interconnected Albion Leach Reactors. The Albion Leach Reactor is an atmospheric leaching vessel that has been designed by Xstrata Technology to achieve the oxygen mass transfer required for oxidation of the sulphide minerals at low capital and operating cost.

Oxygen is injected into the base of the Albion Leach Reactors using Xstrata's HyperSparge™ supersonic injection lances. The design of the HyperSparge™ injection system is carried out in conjunction with the design of the agitation system to ensure high oxygen mass transfer rates are achieved in the reactor. The agitator unit power is moderate, and the impeller tip speed is chosen in combination with the HyperSparge™ injection velocity to provide the required mass transfer rates.

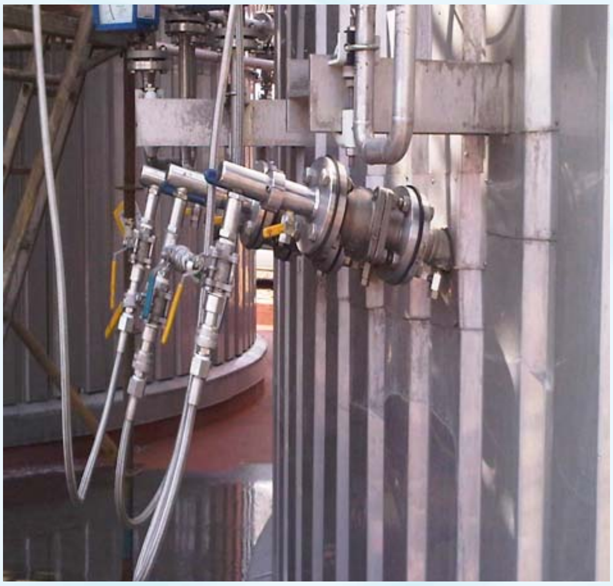
The Albion Leach Reactor has a corrosion resistant alloy steel shell and base, supported on a ring beam or raft foundation. The tank aspect ratio is designed to achieve high oxygen transfer rates and capture efficiencies. Xstrata Technology has developed fully modular tank shell systems, which can be rapidly installed on site in one third the time of a field welded tank and at much lower costs. The Xstrata modular reactor designs require no site welding. The modular Albion Leach Reactor is shown in Figure 6.

Figure 6
Albion Leach Reactor

The reactor is fitted with a centrally mounted agitator consisting of one or more hydrofoil impellers. The agitator sizing and impeller geometry is chosen by Xstrata Technology using in house correlations and testwork data to provide sufficient power to meet the oxygen mass transfer requirements in the leach vessel, as well as provide adequate solids suspension and gas dispersal. Impeller arrangements and spacing are also designed to assist in foam control within the vessel. The agitator is mounted off the tank shell, and modular maintenance platforms and structural supports are provided as part of the Albion Leach Reactor.

Key design aspects of the agitator, such as the solidity ratio, the impeller diameters and tip speeds and the overall pumping rate are determined in combination with the design of the oxygen delivery system to provide the optimum mass transfer rates in the reactor.

HyperSparge™ supersonic oxygen injection lances are mounted circumferentially around the reactor, close to the base. The HyperSparge™ is mounted externally to the tank, and penetrates through the tank wall using a series of sealing assemblies. This design ensures that no downtime is incurred for maintenance of the oxygen delivery system, as all HyperSparge™ units can be removed live for inspection.



The HyperSparge™ injects oxygen at supersonic velocities in the range 450 – 550 m.s-1. The supersonic injection velocities result in a compressed gas jet at the tip of the sparger that incorporates slurry via shear resulting in very high mass transfer rates within the Albion Leach Reactors.

The unique design of the HyperSparge™ means that the agitator power required for the Albion Leach Reactors is much lower than is required in a conventional system. Oxygen capture efficiencies of 85 % or higher are achieved in Albion Plants within the Xstrata group using the HyperSparge™ system. A typical HyperSparge™ assembly is shown in Figure 7. The high jet velocities at the tip of the HyperSparge™ keep the nozzle clean and eliminate blockages.

The HyperSparge™ is incorporated in an overall oxygen addition and control system developed by Xstrata, consisting of in stack off gas monitoring and control of the HyperSparge™ delivery pressure. The oxygen control system is used to maintain high oxygen capture efficiencies within the Albion Leach Reactor.

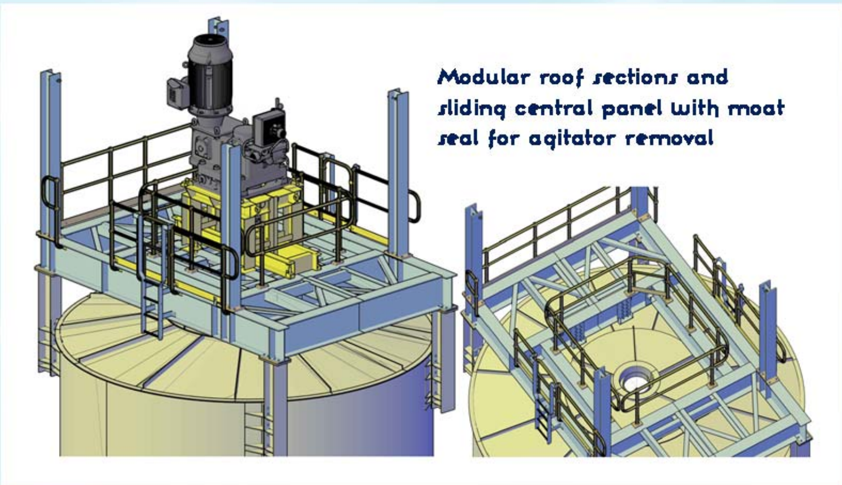


Figure 8
Albion Leach Reactor Roof Section

Exhaust gas from the oxidative leach is inert, and so the Albion Leach Reactor is fitted with sectional lids and an off gas stack to vent steam from the vessel to a safe working height. As the Albion Leach Reactors operate at close to the boiling point of the slurry, significant water vapour is released from the vessel with the exhaust gas, which assists in overall process water balance. The off gas stack is designed as a natural chimney to vent this exhaust gas to a safe working height. The exhaust gas it typically vented, however condensers can be fitted if required to recover the evaporated water. The Albion Leach Reactor has a modular lid assembly, incorporating an agitator moat seal and sliding roof section to allow easy removal of the agitation mechanism for maintenance. This is shown in Figure 8.

Each Albion Leach Reactor has modular Internal baffles to assist mixing and prevent slurry vortexing, as well as a modular slurry riser to prevent slurry short-circuiting and assist in transport of coarser material through the leaching train.

The Albion Leach Reactors are connected in series with a launder system that allows gravity flow of the slurry through the leach train. All Albion Leach Reactors are fitted with bypass launders to allow any reactor to be removed from service for periodic maintenance. This is a low cost leaching system that is simple and flexible to operate, and the overall availability of the oxidative leach train is 99%. Xstrata Technology's launder design accommodates froth, preventing a build-up of foam in the leach train. The Launder Assembly is shown in Figure 9.

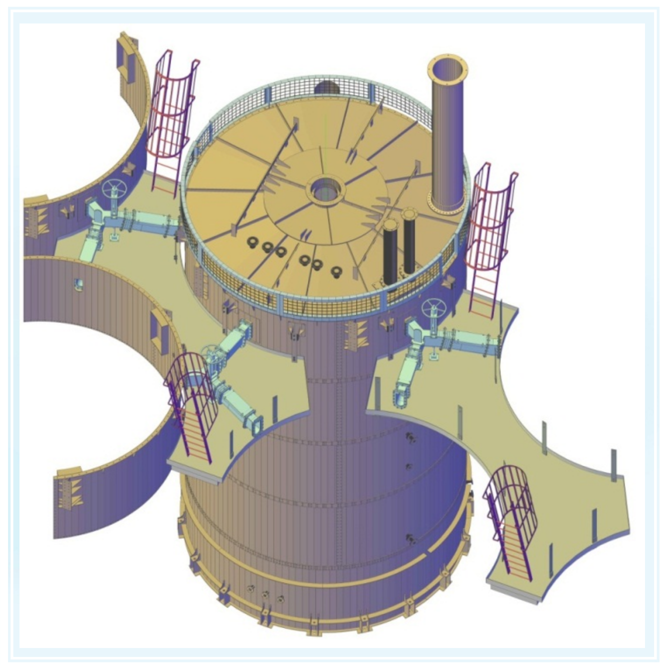


Figure 9
Launder System

No internal heating or cooling systems are required in the Albion Leach Reactors. The vessel is allowed to operate at its equilibrium temperature, which is typically in the range 90 – 95 °C. Heat is provided by the oxidation of the sulphide minerals, with heat lost from the vessel by humidification of off gas. No direct or indirect temperature control is required, simplifying tank construction and maintenance. No external cooling towers or flash vessels are required.

4 Oxidative Leach Chemistry

The Albion Process™ leach circuit oxidises sulphide minerals to either elemental sulphur or sulphate. This process liberates significant heat, and the oxidative leach is allowed to operate at a temperature close to the boiling point of the slurry. Typical operating temperatures are in the range 93 – 98 °C.

At these operating temperatures, mineral leaching will occur in two steps. In the first step, the mineral sulphide is oxidised to a soluble sulphate and elemental sulphur.

Step 1 $$MS + H_2SO_4 + \frac{1}{2} O_2 = MSO_4 + S^o + H_2O \qquad (A)$$

In the second step, the elemental sulphur is then oxidised to form sulphuric acid.

Step 2 $$S^o + H_2O + 3/2\ O_2 = H_2SO_4 \qquad (B)$$

These reactions can be catalysed by the action of ferric iron under acidic conditions. The oxidative leach can be operated under a range of pH conditions, varying from acidic to neutral. The control pH will set the amount of elemental sulphur oxidation via reaction B. The extent of elemental sulphur oxidation can be varied from a few percent to full oxidation by control of the leach pH. This is the main control loop employed in the oxidative leach, with pH or acidity setpoints varied within the range 1 – 6.

For a copper-zinc concentrate, the oxidative leach is operated under acidic conditions. In these systems, the background acidity is held in the range 5 – 15 gpl, and the leach acidity is maintained by either the addition of spent electrolyte from the zinc cellhouse or raffinate from the copper solvent extraction circuit, or by allowing Reaction (B), the oxidation of elemental sulphur, to proceed.

The leach is operated as a ferric leach, with iron liberated by the leaching sulphides, then oxidised by oxygen, to maintain a level of ferric iron in the leach slurry within the range 2 – 5 gpl. Oxygen is supplied as oxygen gas, typically from a VPSA plant at a purity of 93 – 95 % v/v. Acid is provided in the form of spent electrolyte or solvent extraction raffinate, where acid is returned to the leaching circuit from the copper and zinc electrowinning cellhouse.

Elemental sulphur oxidation will proceed readily under the conditions found in the Albion Process™ oxidative leach at acidities below 10 gpl, and slows significantly as the acidity approaches 15 gpl. In this way the Albion acidic leach is self-regulating, oxidising elemental sulphur as required, maintaining the required acidity.

The oxidative leach is a two stage process, where economic metals are first leached in oxygenated acidic solution, with the acidic leach slurry then neutralised to precipitate iron and other deleterious elements such as arsenic, prior to separation of the leached solids and recovery of the economic metals from the neutralised leach solution. Metal recovery can be via conventional processes. Iron removal by goethite or jarosite precipitation is the preferred neutralisation circuit for Albion Process™ acid leach circuits.

4.1 Oxidative Leaching of Zinc Sulphide Minerals

Copper-zinc sulphide concentrates can contain a range of sulphide minerals , however as a general rule, zinc sulphides will leach at a coarser grind size than most copper sulphide minerals. This allows some selectivity in the leaching of zinc sulphides over copper sulphides with control of the grind size. A two stage flowsheet is employed for processing copper-zinc concentrates, with the zinc recovered selectively in the first stage, and then copper is recovered from the zinc leach residue.

In the first stage of the Albion Process™ flowsheet, the copper-zinc concentrate is ground to 80 % passing 35 – 45 microns and then leached the zinc oxidative leach circuit using spent electrolyte from the zinc cellhouse. Sphalerite is the most common of the zinc sulphide minerals, and often occurs in the presence of Galena. These minerals will leach according to the reactions below.

$$2\ ZnS + 2\ H_2SO_4(ia) + O_2(g) = 2\ ZnSO_4(ia) + 2\ H_2O + 2\ S^o$$

$$2\ PbS + 2\ H_2SO_4(ia) + O_2(g) = 2\ PbSO_4(s) + 2\ H_2O + 2\ S^o$$

The zinc oxidative leach is controlled to a discharge acidity of 5 – 8 gpl, and the zinc recovery in this stage of the leach is 90 - 95 %. The remaining zinc is then recovered in the copper leach circuit and returned to the leach stage, bringing overall zinc recovery to over 98 %.

By limiting the extend of zinc leaching in the zinc oxidative leaching stage to 90 - 95 %, very little copper minerals will leach, due to galvanic effects, leaving a high grade zinc leachate for processing through to metal. Any minor amounts of copper that report to the zinc leachate will be removed in the zinc dust cementation circuit and returned to the copper leach circuit for recovery to copper cathode.

4.2 Oxidative Leaching of Copper Sulphide Minerals

After the zinc oxidative leaching circuit, the slurry is filtered and the leach residue, containing the copper minerals, pyrite and the precious metals is ground in a second IsaMill™ stage to bring the particle size down to 80 % passing 12 microns. All copper minerals will leach readily at this grind size.

Chalcopyrite is the most common of the copper sulphide minerals, and will leach according to the reaction below.

$$CuFeS_2 + 2.5\ O_2(g) + H_2SO_4(ia) = CuSO_4(ia) + FeSO_4(ia) + H_2O + S^o$$

Chalcocite and Covellite are the most common secondary copper minerals found in copper sulphide concentrates, and will leach according to the reactions below.

$$Cu_2S + \frac{1}{2} O_2 (g) + H_2SO_4 \rightarrow CuSO_4 + H_2O + CuS$$

$$CuS + \frac{1}{2} O_2 (g) + H_2SO_4 \rightarrow CuSO_4 + H_2O + S^o$$

Copper recovery in the copper oxidative leach will be over 99 %.

All remaining sphalerite in the copper leach feed will also be oxidised in the copper oxidative leach and report to the copper circuit raffinate for neutralisation and return to the zinc leach circuit.

Pyrite is one of the major gangue sulphide minerals present in many sulphide concentrates. The pyrite leach reaction will be:

$$FeS_2 + 7/2O_2 + H_2O \rightarrow FeSO_4 + H_2SO_4$$

Pyrite will not form elemental sulphur at leach acidities below 25 gpl, and so little elemental sulphur formation is expected from pyrite within the oxidative leach circuits. Significant pyrite leaching will not occur until most of the base metal sulphides have leached to completion, due to the galvanic effects, as pyrite is cathodically protected relative to these minerals. For this reason, little pyrite leaching will occur in the zinc oxidative leach, and approximately 20 – 30 % pyrite oxidation is anticipated in the copper oxidative leach.

4.3 Neutralisation

Both iron and sulphur, in the form of sulphates and acid will be liberated in the zinc and copper acidic leach, along with minor levels of other deleterious elements such as arsenic, aluminium and silicon. On completion of the oxidative leach stages, the oxidised slurry will be neutralised to precipitate iron, acid and deleterious elements. Two iron precipitation circuits are commonly employed in mineral sulphide leaching circuits – Goethite and Jarosite. A jarosite circuit is commonly employed after the zinc oxidative leach, to remove iron prior to the zinc dust purification stage. Goethite precipitation is more common after the copper oxidative leach.

The neutralisation circuits will be operated using the same Albion Leach Reactors as used in the oxidative leaching circuit, to ensure commonality of spares and simpler maintenance. The intertank launder system will be the same as employed in the oxidative leach, and all reagent mains will have dosing points extending through the interface between the leach and neutralisation stages. This will allow several tanks to be operated as either leach or neutralisation vessels, providing flexibility for differing concentrate compositions.

4.3.1 Neutralisation following the Zinc Oxidative Leach

The leached slurry from the zinc oxidative leach will contain low levels of iron, as pyrite oxidation will be limited in the zinc oxidative leach. Iron removal may be carried out with the addition of sodium ions to form a jarosite, or via neutralisation at higher pH to form goethite. The choice of iron removal mechanism will depend on the concentrate mineralogy. Jarosite precipitation can be carried out at the natural discharge acidity from the zinc oxidative leach, without the need for neutralisation:

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

The acid level exiting the zinc oxidative leach or jarosite stage will be approximately 5 – 8 grams per litre, and this will be neutralised prior to purification of the zinc leachate. Neutralisation can be carried out using calcined zinc concentrate, where the Albion Process™ plant forms an expansion to an existing zinc refinery, or basic zinc sulphate where the Albion Process™ plant is a standalone facility.

The zinc oxidative leach discharge slurry will initially be neutralised to a pH of 2.8 – 3.2 in the first neutralisation reactor, by adding calcine or basic zinc sulphate:

$$H_2SO_4 + ZnO = ZnSO_4(a) + H_2O$$

$$3H_2SO_4 + ZnSO_4.3Zn(OH)_2 \rightarrow 4ZnSO_4(a) + 6H_2O$$

Both neutralisation options will precipitate any residual iron as goethite at the operating temperatures exiting the oxidative leach.

$$Fe_2(SO_4)_3(a) + 3ZnO + H_2O \rightarrow 2FeO.OH + 3ZnSO_4(a)$$

$$Fe_2(SO_4)_3(a) + ZnSO_4.3Zn(OH)_2 \rightarrow 2FeO.OH + 4ZnSO_4(a) + 2H_2O$$

The neutralised slurry will then be filtered and the solution transferred to the zinc dust purification circuit.

Basic zinc sulphate will be formed by neutralisation of a bleed from the purified zinc solution with either limestone or lime slurry:

$$4ZnSO_4(a) + 3Ca(OH)_2 + 2H_2O = ZnSO_4.3Zn(OH)_2 + 3CaSO_4.2H_2O$$

Neutralisation with basic zinc sulphate is preferred over neutralisation with limestone, as zinc losses to the precipitate are lower, and calcium addition to the downstream zinc purification circuit is limited.

4.3.2 Neutralisation following the Copper Oxidative Leach

The leached slurry from the copper oxidative leach will also require neutralisation to remove excess iron released from chalcopyrite and pyrite oxidation. Iron tenors in solution exiting the copper oxidative leach will be higher than the zinc leach.

A goethite neutralisation circuit will be used to neutralise the slurry following the copper oxidative leach with the following key control parameters:

- Ferric levels in all tanks will be maintained at less than 1 g/L at all times and the temperature is maintained at over 85 degrees. This will ensure that iron precipitates as goethite, and any arsenic as a stable ferric arsenate.

- The circuit will be operated with precipitated solids recycle to partially neutralise acid exiting the leach train and provide seed to the neutralisation circuit. This will enhance crystal growth at the expense of nucleation, and improve the settling and filtration properties of the precipitate.

- The pH profile across the neutralisation circuit will be staged to minimise supersaturation of both iron and sulphate, to ensure a stable precipitate and minimise scale formation.

The copper oxidative leach discharge slurry will initially be neutralised to a pH of 1.2 – 1.8 in the first neutralisation reactor, by adding recycled neutralised product. The pH will then be increased in the subsequent neutralisation vessels to 2.8, with oxygen added to assist ferrous oxidation to ferric. Any residual ferrous iron present in the leach discharge will be oxidised at the more neutral pH to ferric iron.

Ferric iron will then be precipitated as goethite:

$$1/2Fe_2(SO_4)_3 + 3/2CaCO_3 + 5/2H_2O \rightarrow FeO.OH + 3/2CaSO_4.2H_2O + 3/2CO_2$$

Goethite and the analogous phase, ferrihydrite, will be the favoured iron precipitates in the neutralisation stage, due to the operating temperature of approximately 85-95°C. Minor hematite formation will also occur.
Arsenic will be fixed in the residue as a stable ferric arsenate according to the reaction:

$$Fe_2(SO_4)_3(a) + 2H_3AsO_4(a) + CaCO_3 + 5H_2O \rightarrow 2FeAsO_4.2H_2O + CaSO_4.2H_2O + 2H_2SO_4 + CO_2$$

The neutralisation circuit is operated under conditions to ensure a crystalline ferric arsenate is favoured over nucleation and precipitation of amorphous iron arsenic phases.

Either oxygen or air can be used as the oxygen source in the neutralisation stages. Oxygen is recommended to promote the iron and arsenic oxidation kinetics and to prevent excess heat loss due to humidification of off-gas. High temperatures in the neutralisation circuit are important in forming a stable arsenic precipitate.

5 Proposed Process Flowsheet

A process flowsheet for a typical bulk copper-zinc concentrate is shown in Figure 10. A high grade concentrate is not required for the leach circuit, and so it is recommended that rougher flotation only be used to produce the bulk concentrate.

The flowsheet employs dual milling stages. In the first stage, the bulk concentrate is ground to 80 % passing 35 – 45 microns and then subjected to oxidative leaching to recover zinc to solution. Less than 5 % of the copper and iron in the concentrate will report to the zinc leachate, with the zinc recovery limited to 90 %.

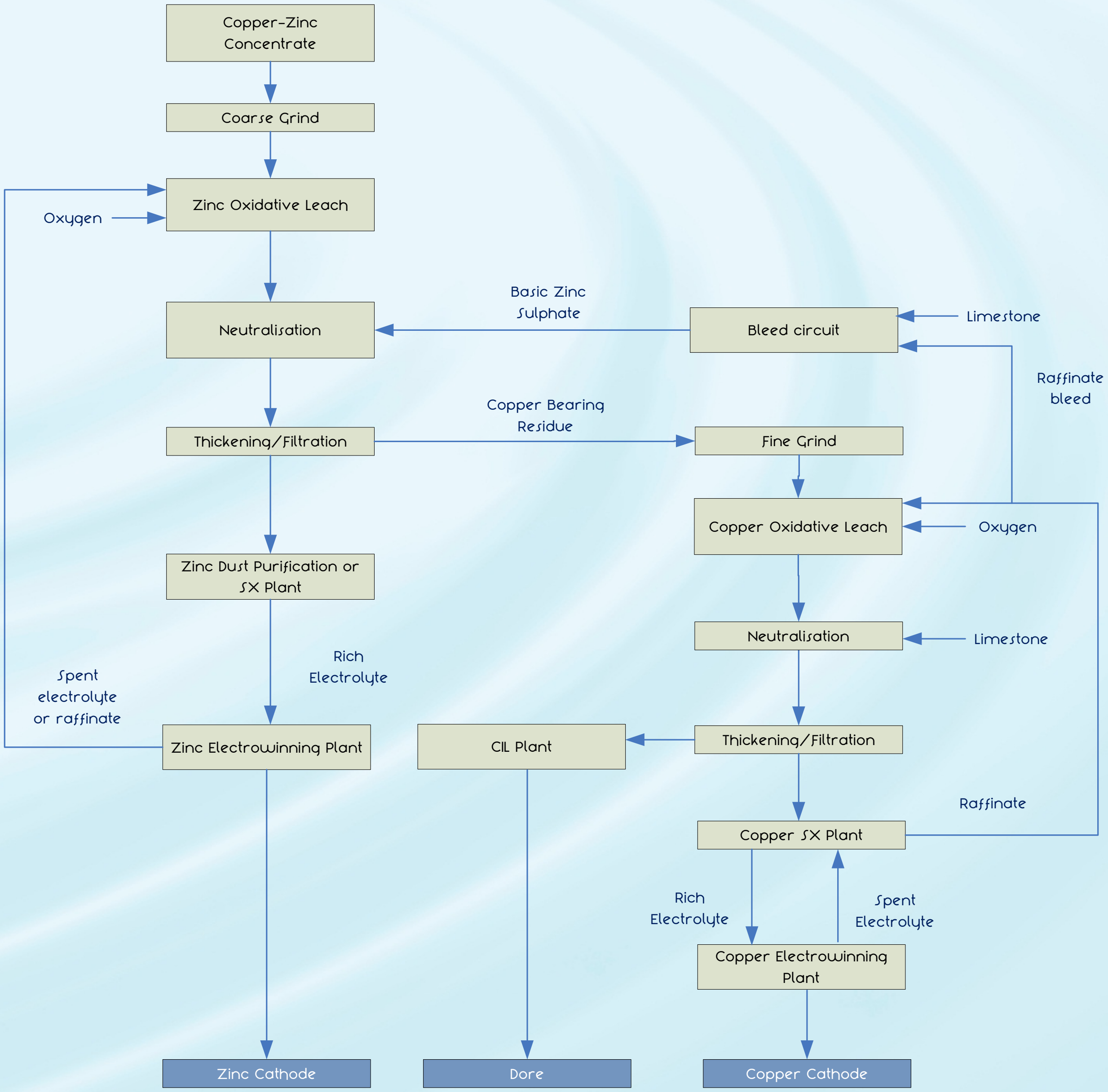
The zinc leach residue is then filtered and transferred to a second grinding stage, where the particle size is reduced to 12 microns to leach the copper minerals. The zinc leachate is neutralised to remove iron, prior to purification of the zinc leachate using conventional zinc dust purification. Zinc solvent extraction can also be considered for purification of the zinc leachate.

The purified zinc leachate is then processed through a cellhouse to recover electrowon zinc cathode. Acid generated in the electrowinning reaction is returned to the zinc leach as spent electrolyte from the cellhouse.

In the copper oxidative leach, the zinc leach residue is ground to 80 % passing 12 - 14 microns and then subjected to oxidative leaching to recover copper and the remaining zinc to solution. The copper leach residue is then filtered and transferred to a cyanide leach plant or sold to a smelter for precious metals recovery. The copper leachate is then neutralised to remove iron, prior to solvent extraction and electrowinning to produce cathode copper.

Acid generated in the copper electrowinning cellhouse is returned to the copper leach circuit as raffinate. A bleed of the raffinate is periodically neutralised to remove excess water from the circuit. The bleed circuit precipitate will contain the remaining zinc that is leached in the copper leach circuit, and so this precipitate is transferred to the zinc circuit and the precipitated basic zinc hydroxides used in the neutralisation circuit preceding the zinc purification circuit.

Figure 10
Albion Process Flowsheet – Bulk Copper-Zinc Concentrates



Xstrata Technology is the developer and owner of the Albion Process™ technology and offers the technology to clients worldwide.

Xstrata Technology provides lump sum equipment design and supply packages to all Albion Process™ clients. The scope of supply includes the full Albion Process™ plant, inclusive of all structural steel, piping and launders, platforms, stairways and support structures. Full civil and foundation design can be included in the Xstrata Technology scope of work. Construction is supplied by the client, with supervisory labour provided by Xstrata.

The Albion Process plant package provided by Xstrata Technology is low cost and low risk, and incorporates all of Xstrata's knowhow in the 20 year development history of the IsaMill™ and Albion Process™ technologies. Xstrata Technology can work with our client's EPCM contractor to ensure that the Albion Process™ plant interfaces with all other plant areas in an efficient manner.

Xstrata Technology involvement in a project usually begins at the testwork stage, with a testwork and project development program designed for the client by Xstrata and our marketing partner Core Resources. All testwork is carried out at an approved testing facility. Xstrata can provide a range of Engineering Studies in support of the testwork programs to provide capital and operating cost data for the Albion Process™ plant. Xstrata Technology can also provide Feasibility Study services, ultimately leading to a lump sum equipment design and supply package, which is fully guaranteed by Xstrata.

As an introduction to the Albion Process ™ technology, Xstrata can provide desktop capital and operating cost estimates for an Albion Process ™ plant at no cost to our clients, once provided with a concentrate composition and planned throughput.

For more information on the Albion Process™, please refer all enquiries to:

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Xstrata operates mines throughout the world.

Tough testing grounds that make our process technologies the best on earth.

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