Albion Process™ Hub for Refractory Gold Concentrates

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ABSTRACT

Gold hosted in refractory sulphides has historically been overlooked in preference of easily recoverable gold which requires less upfront capital. However, as reserves of these ores become depleted in the face of continuously increasing gold demand, opportunities arise for forward looking companies to capitalise on the requirement for pre-treatment of sulphide-hosted gold. Gold hosted in refractory sulphides requires pre-treatment to oxidise the sulphide minerals, releasing the gold and making it amenable to recovery via traditional Carbon-In-Leach (CIL) processes. Several established options exist to liberate sulphide hosted gold, but the key to maximising this opportunity lies in the selection of an approach that is sufficiently flexible to manage variations in feed whilst still achieving high recoveries.

This paper will focus on Glencore Technology's Albion Process™ as a robust pre-treatment solution for refractory gold feeds that may vary significantly in their throughput and mineralogy and contain high levels of impurities such as arsenic. The Albion Process™ uses a combination of mechanical and chemical liberation of the gold via ultrafine mineral grinding and oxidative leaching at atmospheric pressure. The simplicity of this process combined with the tight size distribution achieved using the IsaMill™ and high oxygen utilisation afforded by the HyperSparge™ and OxiLeach™ reactor designs allows for significant variability in the feed to any Albion Process™ plant without compromising recovery. This opens the door for an Albion Process™ plant refractory gold treatment hub capable of toll treating concentrates produced from a multitude of external ore bodies. Real world examples will be used to demonstrate how one Albion Process™ plant can accept significant variation in feed composition and rate and still achieve high gold recoveries.

INTRODUCTION

Gold hosted within refractory sulphides is often perceived as too difficult to extract and recover and is therefore overlooked in favour of easily recoverable free milling gold. As reserves of free milling gold become depleted in the face of increasing gold demand, the requirement to treat these deposits is also increasing. The cost associated with the construction of a processing plant to treat refractory sulphides can be significant. Facilities that are able to deal with variable feed characteristics can unlock opportunities for both process plant operators by maximising available feed and essentially prolonging the life of the operation, as well as for other mining operations who may be unable to treat their sulphide material, by providing an opportunity to sell concentrate.

The Albion Process™ is an ideal technology for this scenario as it provides flexibility in terms of mineralogy, throughput, oxidation extent and residence time. The features of the Albion Process™ that underpin this flexibility will be outlined in this paper along with real world projects which demonstrate how an Albion Process™ plant is intended to be used as a processing hub.

THE ALBION PROCESS™

The Albion Process™ was developed by Glencore in 1994 and is a globally patented technology comprising two steps. The first step is ultra-fine grinding using the IsaMill™ (Figure 1) to minimise potential passivation of the leaching sulphide and increase surface area available for oxidation during the Albion Process™ leach.

Figure 1: Model of IsaMill™ Plant

The second step comprises oxidative leaching of the finely ground sulphide concentrate utilising the HyperSparge™ for oxygen injection in Glencore Technology's Oxidative Leach Reactors (OxiLeach™, Figure 2) which operate auto thermally at atmospheric pressure. Figure 1: Model of IsaMill™ Plant

Figure 2: OxiLeach™ Reactor Train

The oxidative leach can be operated under a range of pH conditions, varying from acidic to neutral and has been commercialised in zinc and gold with five plants currently in operation. These have been reported on extensively (Hourn & Turner, 2010; Hourn & Turner, 2012; Voigt, Hourn, & Mallah, 2016; Senshenko, Aksenov, Vasiliev, & Seredkin, 2016). Albion Process™ oxidative leaching under conditions closer to neutral (pH 5.5) is optimal for the oxidation of pyrite, arsenopyrite and other gold bearing minerals, to break down the sulphide matrix and render the precious metals amenable to downstream cyanidation. In order to maintain the leach at the target pH of 5.5, limestone is dosed into each reactor to neutralize the acid generated by the pyrite oxidation reaction:

$4FeS_2 + 15O_2 + 18H_2O + 8CaCO_3 \dashrightarrow 4FeO.OH + 8CaSO_4.2H_2O + 8CO_2$

During this process, any arsenic that may be present will coprecipitate with iron, forming a stable ferroarsenate (predominantly scorodite). As such the Albion Process™ is capable of handling high arsenic feeds and yields a residue with arsenic species that are inert and safe for tailings.

When Albion Process™ leaching occurs under acidic conditions, base metal sulphides are oxidised and the target metals simultaneously leached into solution. Gold bearing sulphide minerals such as pyrite will also oxidise according to the above reaction, albeit at a slower rate compared to those exhibited at the higher pH of a 'neutral' leach. On completion of the acidic leach, a distinct neutralisation stage serves to remove iron and arsenic from solution via the dosing of limestone to allow for the coprecipitation of these elements as described above. As the precious metals remain in the solid residue, a subsequent thickening stage will direct the leach solution to downstream processing (SX/EW, precipitation, etc.) for the recovery of base metals, whilst the precious metals within the residue are directed to the cyanide leach.

The ability to operate at different chemistries, handle variation in feeds and process high arsenic concentrates makes the Albion Process™ ideal for treating precious metal concentrates, or complex polymetallic concentrates which contain base metals along with precious metals that are finely disseminated through the sulphide matrix.

HYPERSPARGE™

The HyperSparge™ is a proven and cost-effective sparging system for delivering air, oxygen, or other gases for leaching or oxidation processes and is a key component of the Albion Process™ OxiLeach™ reactors. The system uses an alloy steel injection lance fitted with a hard-wearing ceramic nozzle to inject a concentrated supersonic jet of gas into the process solution or slurry. The supersonic gas jet enters the process stream at velocities exceeding of 400 m/s, creating a region of very high local shear and fine bubbles, resulting in very efficient oxygen mass transfer and therefore high gas utilisation.

PROCESSING HUB PHILOSOPHY

As outlined above, historically, processing refractory sulphides has been overlooked in favour of free milling gold hosted in oxides. As operations deplete the oxide portion of their deposits and begin to move into the transition and sulphide regions of an ore body, gold recoveries decline, as refractory gold is typically unamenable to direct cyanidation. This is often the point at which operations will cease and/or the operator of the mine will focus on another deposit. As reserves of free milling gold are progressively depleted and become harder to find, the viability of treating sulphide deposits is increasing to ensure demand can be met.

However, circuits to treat sulphide deposits present with increased complexity compared to their simpler oxide treatment counterparts, and the capital associated with building (or retrofitting) a plant to treat sulphide ores can be prohibitive to some operations, particularly junior mining companies. This may present a unique opportunity for forward looking companies who have the capacity to undertake larger projects. The robustness of the Albion Process™ would allow for the design of a processing plant for a specific deposit with sufficient flexibility installed to allow for the treatment of third-party feeds from other deposits. This flexibility is achieved across both stages of the Albion Process™. In the first stage, ultra-fine grinding, the IsaMill™ affords flexibility in the grind size that can be achieved, as the setup can be adjusted to target both finer and coarser grind sizes pending the requirements of each unique concentrate.

In the second stage of the Albion Process™, oxidative leaching, the OxiLeach™ reactors can be configured as either an acid or neutral Albion Process™ depending on whether there are base and precious metals present or just precious metals. For periods of decreased throughput or for concentrates that require lower residence time, up to half of the OxiLeach™ train can be bypassed, thus decreasing wear and tear on equipment. On the other end of the spectrum, the OxiLeach™ train can easily be expanded with the addition of extra reactors, a change that is not always achievable with some alternative technologies. The opportunity to target residence time coupled with the HyperSparge™ system also allows sulphide oxidation targets to be adjusted to suit specific feeds. These features mean that the Albion Process™ is well suited for a hub style processing plant capable of treating various concentrates from particular regions, reinforcing the opportunity for both the company who constructs the plant, and the companies who would then have a path to sell concentrate. As the Albion Process™ is capable of treating relatively ‘dirty’ or ‘low grade’ it provides the added benefit of lowering the cut-off point for what might be considered a ‘saleable’ concentrate for other mines that may not have the processing capabilities to produce final metal.

The following sections provide examples of gold processing hub projects that are is currently being undertaken by JSC Altynalmas (Altynalmas).

NEUTRAL HUB – PUSTYNNOYE PROJECT

Altynalmas has been developing a number of gold deposits in Kazakhstan and are progressing two Albion Process™ projects. The first of these is the Pustynnoye Neutral Albion Process™ Hub. The processing plant for this project has been designed to treat concentrates from four precious metal deposits; Pustynnoye, Kariernoye, Aksu and Sayak. Characterisation results for the individual concentrates generated from each of these deposits exhibited significant variation, summarised below:

Gold: 15.2 – 57.5 g/t
Silver: 1.9 – 94.0 g/t
Iron: 18.2 – 35.3%
Sulphur: 11.9 – 38.2%

As expected, the gold hosting minerals pyrite and arsenopyrite also varied greatly between concentrates with ranges as follows:

Pyrite: 2.0 – 70.0%
Arsenopyrite: 3.5 – 65.0%

For this project, the optimum grind size was determined to be 80% passing 8 µm. Although this is at the finer end of what would typically be required for high recoveries in the Albion Process™, sizing the IsaMill™ using this fine grind size was logical to allow the plant to accept highly variable concentrate feeds. The test work was conducted on two sperate master composite blends of the concentrates labelled as 'Pustynnoye blend' and 'Kariernoye blend'. Extensive testwork was undertaken to optimise conditions and confirm the recovery results after the Albion Process™. Despite the variability between the two composites, gold recoveries increased from 45.4% (untreated concentrate) to 93.2% and 91.9% after oxidative leaching for the two blends, respectively. These results along with the recovery post ultrafine grinding alone are summarised in Figure 3.

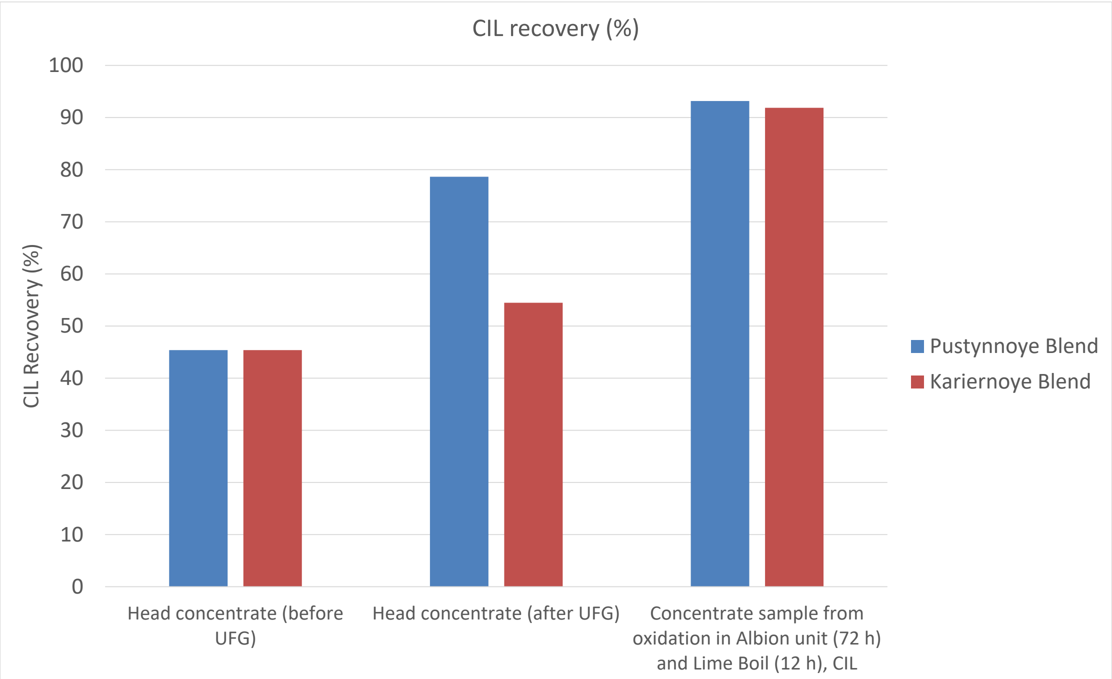

Figure 3: CIL Recoverable Gold for Pustynnoye Project

The consistency in gold recovery despite the notable differences in feed characteristics reinforced the flexibility of the Albion Process™ with regard to significant feed variation, making it an ideal option for meeting the project objective of treating feeds from four different deposits. It also de-risked the option of developing further deposits, which is currently underway with drilling being conducted in the Akbakai mine cluster which consists of another three refractory ore bodies.

ACID HUB – MIZEK PROJECT

In addition to the Pustynnoye Neutral Albion Process™ Hub, Altynalmas are also progressing the Mizek Acid Albion Process™ Hub. The purpose of this hub is to process the polymetallic concentrates that contain both base and precious metals. The initial hub design has been based on the Mizek concentrate which contains copper, zinc, gold, and silver. The Mizek concentrate specifications used in the design of the processing plant are as follows:

Gold:	16.2 g/t
Silver:	52.4 g/t
Iron:	29.3%
Sulphur:	39.8%
Copper:	7.0%
Zinc:	16.0%

With the metals predominantly hosted in the following minerals:

Pyrite:	57.0%
Sphalerite:	22.0%
Chalcopyrite:	9.0%

The optimum grind size target for this project was also determined to be 80% passing 8 µm. As mentioned above, sizing the mill using the finest required grind size enhances flexibility by increasing the range of feeds and variability that the plant can accept. Extensive testwork was undertaken to optimise leach conditions and confirm the gold recoveries achievable via the Albion Process™. After oxidative leaching, CIL gold and silver recoveries increased from 28.9% as received to 95.2% for gold and from 25.3% to 95.4% for silver.

These results along with the recovery post ultrafine grinding alone are summarised in Figure 4.

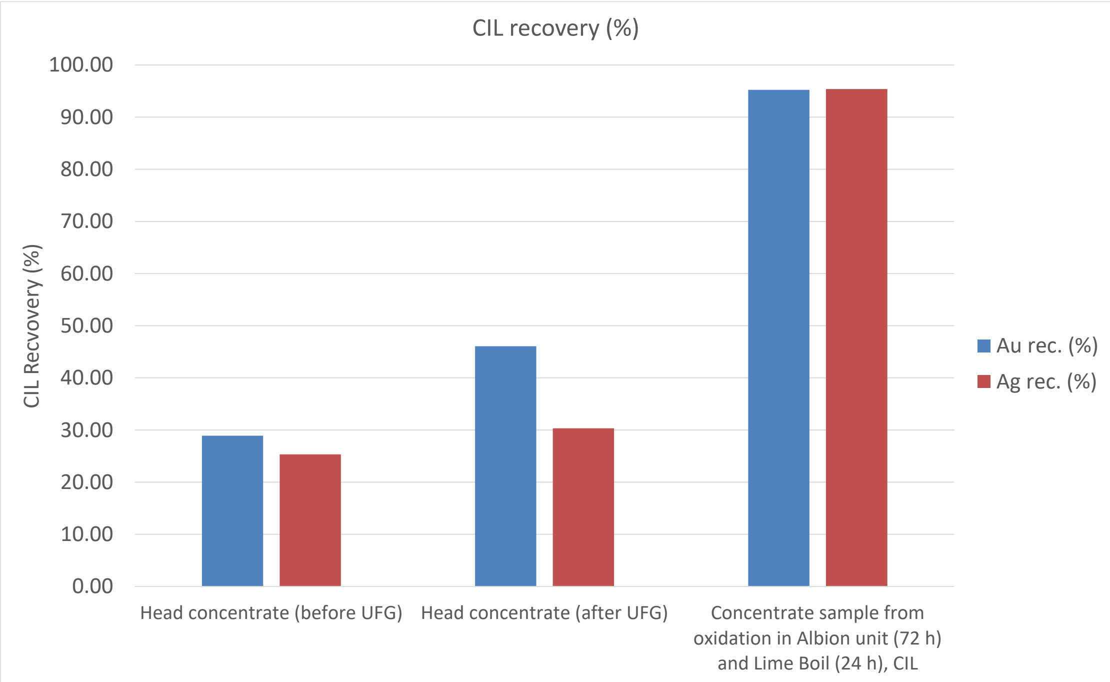

Figure 4: CIL Recoverable Gold and Silver for the Mizek Project

Test work for base metals also indicated that Albion Process™ leaching achieved excellent zinc recoveries (99.5%) and high copper recoveries (91.8%) at a sulphur oxidation of 96.7% (Figure 5).

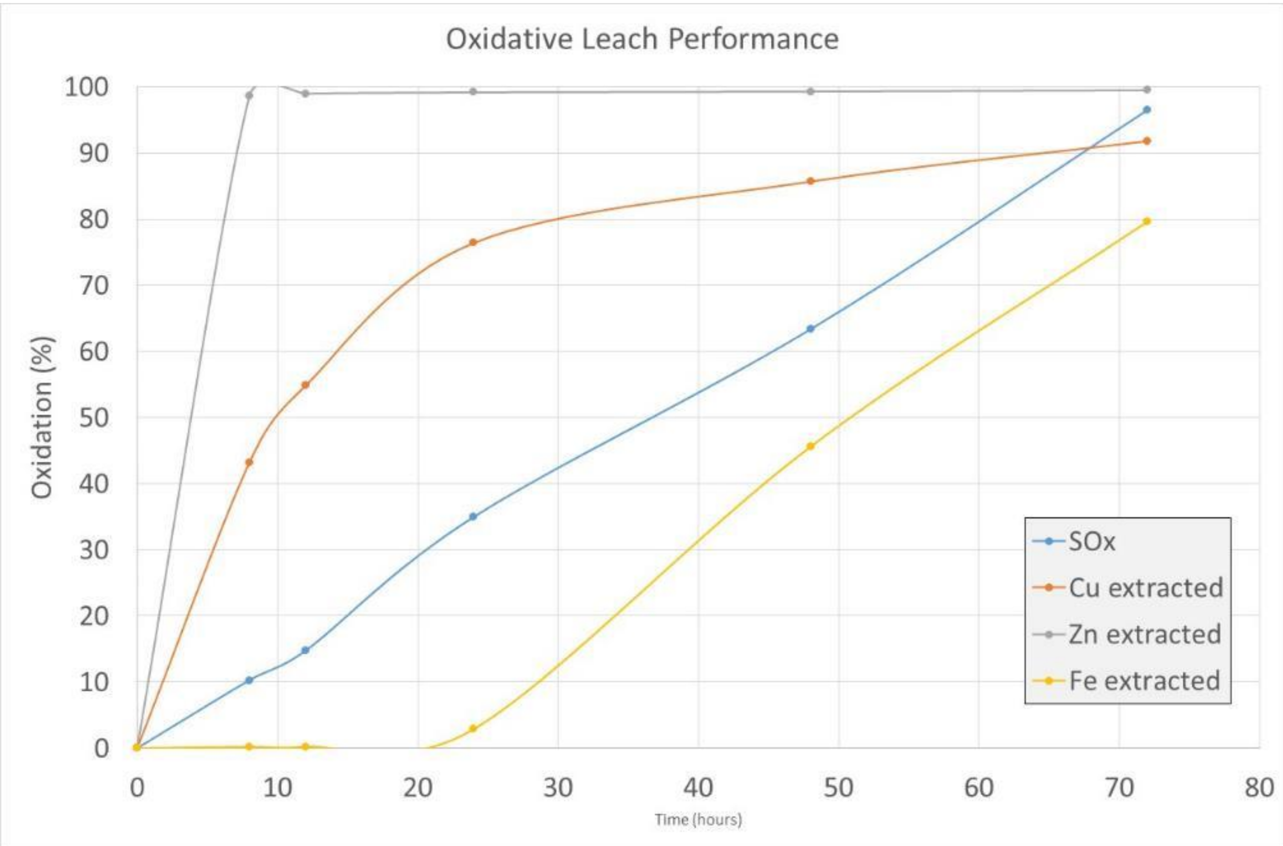

Figure 5: Oxidative Leach Performance for Mizek Project

The Sayak deposit is also being considered as feed for the Acid Albion Process™ Hub and has the following specifications:

Gold:	46.2 g/t
Silver:	23.1 g/t
Iron:	26.1%
Sulphur:	18.3%
Copper:	0.61%
Cobalt:	0.84%

Differently to the Mizek Cu-Zn deposit (upon which the processing hub has been designed) the primary base metals to be targeted in Sayak are copper and cobalt. As precipitation was selected as the downstream base metal processing option, the precipitation stages can be modified to target different base metals. This will allow for copper and zinc products to be produced initially from Mizek, before changing to produce copper and cobalt products at a later stage when the feed changes to Sayak.

The overall Mizek Acid Albion Process™ Hub is shown in Figure 6 with the IsaMill™ and base metals thickening and filtration located on the left, the OxiLeach™ reactors and two stages of base metal precipitation in the middle section, and iron control filtration and lime boil areas on the right.

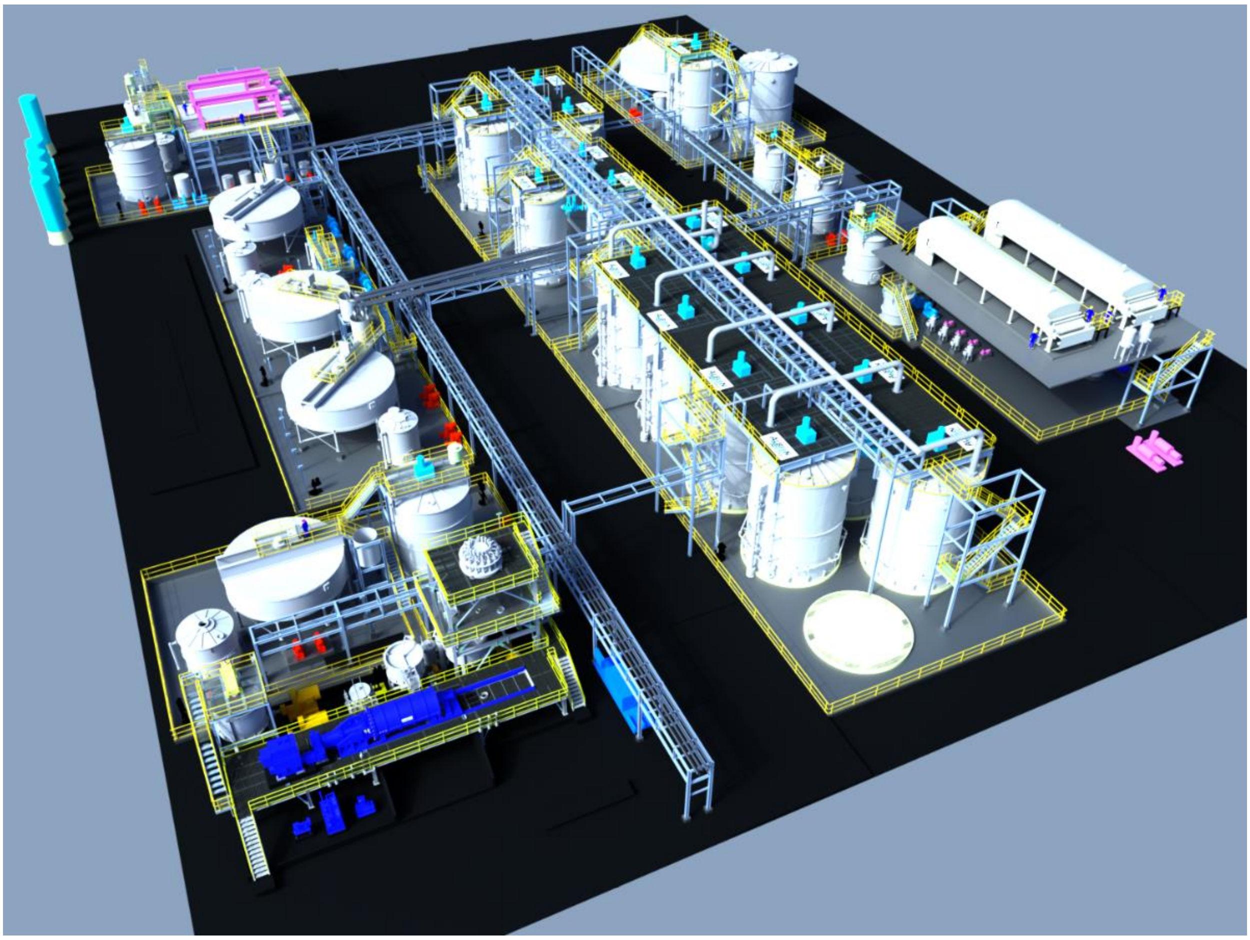

Figure 6: Mizek Acid Albion Process™ Layout

BENEFITS OF THE ALBION PROCESS™

The Albion Process™ offers a number of advantages over other leaching technologies due to the nature in which it operates. Previous investigations have indicated a lower oxygen consumption for the Albion Process™ when compared to medium temperature pressure oxidation (MT-POX) (SNC Lavalin, 2009). This is due to the opportunity to target the extent of the sulphur oxidation required to achieve high metal recoveries when using the Albion Process™, whereas in MT-POX 100% of sulphides are oxidised. Additionally, the HyperSparge™ and impeller design in the OxiLeach™ reactors afford high oxygen usage efficiency. This results in lower capital cost associated with the oxygen plant as well as lower ongoing operating costs.

As the Albion Process operates autothermally and at atmospheric pressure, power input is also decreased in comparison to POX (Alymore, 2012), improving costs and lowering environmental impact. Adding to the environmental benefit, the Albion Process™ has also been shown to use significantly less water than MT-POX (SNC Lavalin, 2009). The autothermal and atmospheric nature of the operation has the additional benefit of not needing any pressure reduction or heat removal. This contributes to a more stable process that simpler to operate.

Albion Process™ availability is also very high due to:

- The oxidative leaching train consisting of multiple reactors in series which are interconnected with launders, each with a bypass. This launder system allows individual reactors to be taken out of operation while online.
- The HyperSparge™ design allows removal and replacement while online.

These features give the ability to maximise throughput even during periods of maintenance.

CONCLUSIONS

This paper outlines how the Albion Process™ can be set up as a hub style processing plant and used to treat multiple feeds, whether they be for precious metal, base metal, or polymetallic feeds. The key to this flexibility is the ability to adjust operation of the IsaMill™ and OxiLeach™ stages, where required, to suit varying feeds. As discussed, the oxidative leaching capacity can be expanded by simply adding more reactors to the train. This ability to expand cannot be matched by some alternative technologies.

This hub style design allowing toll treating of different feeds provides benefit for both the operator of the plant because it maximises the available feed for their plant, and other miners who may have sulphide deposits that they are unable to process alone and would be able to supply the concentrates to feed the plant.

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