Ausmelt vs Pressure Leaching

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Auszwehm versus pressure leaching

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Auszwehm Technology has been introduced in the past few years as a new pyrometallurgical route for the treatment of copper concentrates and has been extended for the treatment of zinc and nickel sulphide concentrates as well. It is shown here that pressure leaching of these concentrates should be more suitable because of the simple flowsheet.

In the past fifty years, metallurgists have been vigorously searching new methods to replace the traditional smelting route for copper production. A comparison between the pyrometallurgical routes for sulphide concentrates can be outlined in the following points:

Sulfur dioxide generation During the pyrometallurgical treatment of copper sulphide ores, if SO₂, formed in high enough concentration, it must be used for making acid and nearby market for this acid must be found. If the SO₂ concentration is too low for making acid, disposal methods must be found. These are available but expensive. As a result, in many cases SO₂ is simply emitted to the atmosphere. On the other hand, copper sulfides can be treated by hydrometallurgical methods without generating SO₂, thus the independence of sulphuric acid manufacture. In addition elemental sulphur can be recovered; it can be easily stockpiled or transported at low cost.

Material handling In the pyrometallurgical process, the metallurgist is forced to transfer molten slags and matte from one furnace to the other in large, heavy, refractory-lined ladles. Beside the inconvenience and the cost of handling these materials, there is also the inevitable gas emission from them because they are usually saturated with SO₂ and during transfer they cool down a little resulting in decreased gas solubility hence the inconvenient working conditions. In hydrometallurgical plants, solutions and slurries are transferred by pipelines without any problem.

Energy consumption Because of the high temperatures involved in the pyrometallurgical process, which is usually around 1200 °C, the reaction rates are high but much fuel will be needed. To make a process economical, heat recovery systems are essential. Heat can be readily recovered from hot gases, but rarely from molten material like slag or metal. Thus, a great deal of energy is lost. Further, the equipment needed for heat economy is bulky and expensive. In the hydrometallurgical process, on the other hand, less fuel is needed because of the low temperatures involved (usually 100 - 200°C). Heat economy is usually no problem.

Dust formation Combustion of fossil fuels in furnaces results in the formation of large volume of gases that carry over large amounts of fine dust. This must be recovered to abate pollution and because the dust itself is also a valuable material. The technology of dust recovery is well established but the equipment is bulky and expensive.

In hydrometallurgical processes, this is no problem because wet material is usually handled.

Economics The economics of a pyrometallurgical process is usually suitable for large scale operations and this requires a large capital investment. On the other hand, hydrometallurgical processes are suitable for small scale operations that can be increased when needed and therefore requires low capital investment. Hydrometallurgy may also fit a special need that cannot otherwise be met.

Auszwehm technology

The Auszwem Technology bath smelting system has been invented for the recovery of nonferrous and ferrous metals from a range of feed stocks including concentrates, secondary materials, residues and dross, precious metal-containing materials, and for the processing of a range of industrial by-products. Central to the high-intensity Auszwehm furnace system is the vertically suspended lance submerged in a molten slag bath. Process gases (air and oxygen) are injected through the lance. Fuel also passes down the lance and is combusted at the lance tip to heat the furnace. The slag is well mixed by the
injection of the process gases. Controlled swirling of the process gases inside the lance cools the outer section sufficiently to solidify a layer of slag around the outer surface of the lance. This provides a protective coating in the highly aggressive bath environment.

Feed materials, fluxes, and coal are delivered through a port in the roof of the furnace and drop directly into the molten bath (Fig. 1). If materials are fine they can be agglomerated or injected directly into the bath to minimise dust loss through entrainment in rising exhaust gases. Feed material dissolution, energy transfer, reaction and primary combustion all take place in the slag layer. The intense agitation in the vessel caused by gas injection ensures that reactions occur rapidly and residence times are low.

The degree of oxidation and reduction is controlled by adjusting the fuel to oxygen ratio supply to the lance, and the proportion of coal to feed. This enables the furnace to be operated at strongly oxidising through to strongly reducing conditions. Operating temperatures range from 900 °C to 1400 °C. The Generation 3 lances offered by Ausmelt are constructed from a composite of stainless and mild steel and incorporate specially designed helical gas swirlers that enable the use of low pressure air and oxygen. Ausmelt lances are not consumed, but the lance tips do wear and are repaired in a simple and inexpensive procedure with minimal disruption to operation. Lances can also be fitted with a dedicated shroud section that delivers controlled volumes of air for post combustion of volatile matter and metals. The subsequent energy generated is partially recovered to the process by the splashing bath.

**Copper**

Ausmelt’s copper technology is an integrated system made up of smelting, settling and converting furnaces that produce blister copper from concentrates, secondary materials, or a combination of concentrates and secondary materials. To service the current and future requirements of the copper industry, Ausmelt continuous converting enables large scale copper converting to produce blister directly from matte using iron-silicate slag.

In a recent paper by Olper et al [2] the authors proposed the following flowsheet (Fig. 2): the white metal and/or high grade matte produced in the Ausmelt furnace is crushed and ground to less then 40 µm then leached at 90 °C for 3 hours by a mixture of fluoroboric acid and ferric fluoroborate in a stirred reactor to produce a copper fluoroborate solution:

\[
\text{CuS} + 2\text{Fe}^{2+} + 4\text{BF}_4^- \rightarrow \text{Cu}^{2+} + 2\text{Fe}^{3+} + 4\text{BF}_4^- + x\text{S}^2^- \quad (1 < x < 2)
\]

This operation produces a copper fluoroborate solution which is sent for electrolysis and a sulphur residue which contains the precious metals. The leach solution is then fed to the cathodic compartment of a diaphragm electrolytic cell where copper is deposited on a stainless steel cathode according to:

\[
\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} + 2\text{BF}_4^-.
\]

The catholyte passes through the diaphragm to the anodic compartment where ferric fluoroborate is regenerated on a graphite anode:

\[
2\text{Fe}^{3+} + 2\text{BF}_4^- \rightarrow 2\text{Fe}^{2+} + 2\text{BF}_4^- + 2e^-.
\]

The overall cell reaction can be expressed as:

\[
\text{Cu}^{2+} + 2\text{Fe}^{2+} \rightarrow 2\text{Cu} + 2\text{Fe}^{3+}.
\]

**Zinc**

Ausmelt Technology is also used to recover zinc, lead, silver, and other metals including indium and germanium from many waste and primary zinc-bearing feeds. Five commercial plants use Ausmelt Zinc Technology. Korea Zinc operates a large Ausmelt plant consisting of two furnaces to treat 120,000 tonnes a year of electrolytic zinc leach residues. A second plant is used to process 100,000 tonnes a year of QSL slag. A third plant treats 100,000 tonnes a year of tailings to form zinc. These plants are part of a tightly integrated circuit at Korea Zinc’s Onsan facility that also incorporates three other Ausmelt plants to optimise metal recovery [1].

**Nickel**

Ausmelt Smelting and Converting technology is also applicable to nickel sulphides and polymetallic nickel sulphides. In a process similar to copper smelting, nickel sulphide concentrates are smelted in a continuous operation using Ausmelt Technology to produce a nickel matte. Nickel matte and slag are removed continuously as a mixed liquid into a settling furnace for separation of the matte. The slag from the settling furnace typically contains 0.25% Ni. Nickel Converters using Ausmelt Technology convert the smelted nickel matte to produce high grade matte containing ~70% Ni. Converting is a continuous, single
stage operation that makes a high-grade matte product, tapped periodically from the furnace for conventional downstream electro-refining. The first of two Ausmelt converting furnaces to be constructed as part of the modernisation of Anglo Platinum's Rustenburg plant, South Africa is now in full operation, with the second under design and construction. Ausmelt Nickel Converter technology is being used by Anglo Platinum to reduce overall plant SO₂ and solid emissions by replacing the existing six Peirce Smith converters [1].

**Pressure leaching**

**Copper**

The major advantage of the hydrometallurgical route is that elemental sulfur can be obtained directly during the processing of sulphide concentrates thus liberating the copper industry from the sulphuric acid problem [3]. Two points should be considered when evaluating this technology:

- Chalcopyrite is different from other copper sulphide minerals in being the most resistant to leaching unless high temperature and sometimes high pressure are used. Therefore, a process developed for leaching chalcocite will not apply for chalcopyrite since chalcocite can be solubilized under very mild conditions.

- Many copper deposits are associated with arsenic minerals that render their treatment by a hydrometallurgical route more acceptable than a thermal route since residues and effluent can be put under control.

A successful process should fulfill the following requirements:

- The process should be exothermic, thus no fuel should be needed and the heat generated could be efficiently recovered.

- The oxidizing agent should be the cheapest available and not need regeneration.

- The iron component of chalcopyrite should be obtained as a residue in a minimum number of steps, preferably during leaching.

- The precious metals in the concentrate could be recovered.

These conditions are met during the aqueous oxidation of sulphide concentrates by oxygen in acid medium at high temperature and pressure. The process becomes self-sufficient with respect to the acid used when the copper-containing solution is electrolyzed or precipitated by hydrogen under pressure. The process is usually conducted at about 150 °C and at 1500 kPa. By means of a series of flash tanks maximum heat economy can be achieved (Figures 3 and 4). Aqueous oxidation of the copper concentrate can be conducted continuously in a pressure reactor (Figure 5). The residue from the leaching operation, after flotation of sulfur, should be agglomerated with Portland cement and stockpiled on an impervious base, in the form of dumps to be treated by cyanidation for precious metals recovery. Selenium and tellurium will be associated with the elemental sulfur.

A plant started in 2003 to recover copper from chalcopyrite concentrates by Phelps Dodge at Bagdad mine in Arizona [2]. Leaching takes place at 220 °C in autoclaves in presence of oxygen at 700 kPa (total pressure 3,300 kPa). After solid-liquid separation the acidic copper sulfate solution is used to leach copper oxide ore in heaps. The solution is then processed in a solvent extraction electrowinning circuit to recover copper. In 2006 the same company started building another plant operating at 150 °C to recover elemental sulfur.

**Zinc**

There are now 4 plants operating smoothly using this technology for leaching of zinc sulphide concentrates in dilute sulphuric acid at 150 °C and under oxygen partial pressure of 700 kPa. Acid generated during electrolysis of zinc sulphate solution is recycled in the leaching step.

**Nickel**

Recently, INCO applied pressure leaching technology to treat the newly-discovered sulphide deposits at Voisey Bay in the Canadian North (Figure 6). The process solves the SO₂ problem associated with the treatment of nickel sulphide concentrates, and it is believed that it will have an important

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**Fig. 3: Pressure leaching plant**

**Fig. 4: Pressure leaching of copper sulphide concentrates and precious metal recovery from residue**
Fig. 5: Typical autoclave for leaching sulphide concentrates

Future impact not only for the low-grade material but also for the high-grade concentrate.

When pyrrhotite concentrate is suspended in dilute acid and subjected to aqueous oxidation in an autoclave at 110 °C and 4,000 kPa oxygen partial pressure, the following overall reaction takes place:

\[ 2 \text{FeS} + 3/2 \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3 + 2 \text{S} \]

Any nickel (or copper) will go in solution from which it can be recovered by electrolysis while the platinum metals, usually associated with nickel, will be found in the residue from which they can be recovered. This process which was developed at the Mines Branch in Ottawa in 1955 has the following ad-

vantages:
- Elemental sulphur is formed instead of SO₂
- Nickel is solubilized in a single step (pressure leaching)
- Acid consumed in the reaction is equivalent to the nickel solubilized, and this can be recovered in the electrowinning step

Conclusions

It is believed that pressure leaching of sulphide concentrates followed by electrolysis in conventional sulphuric acid medium [or precipitation by hydrogen in case of copper] is a simple technology that solves the sulphur problem in metallurgy. It is now applied in the copper, zinc, and nickel industries.

References

[1] Ausmelt web site

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