TECHAPPLICATION

Solvent Extraction/Electrowinning Expands Copper Ore Sources

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THE CHALLENGE:
Develop Innovative, Low-Cost, Environmentally Attractive Processing to Enhance Competitiveness of U.S. Copper Industry

Until recently, low-grade copper oxide ores, copper sulfide orebody waste, and secondary sulfides were often treated as waste by many copper processors. For some of these materials the copper recovery rates did not justify the processing costs; for others, the location of the ore was too deep for economical, traditional mining. Then, in the early 1980s, the price of copper fell and generally stayed depressed. Meanwhile, foreign mines, operating with high-grade ores, low-cost labor and often copper-dependent economies, became dominant forces in the field.

The results were significantly reduced copper output by many U.S. producers, the spin-off of operations by others, and even the closing of many mines.

In the 1970s, however, a technology was applied to copper processing that, until the 1960s, had been used primarily for uranium. This was "solvent extraction" for the treatment of copper sulfate leach solutions to produce a rich copper electrolyte.

Coupled with electrowinning to recover copper from this solution, the "solvent extraction-electrowinning" (SX-EW) process significantly reduces:

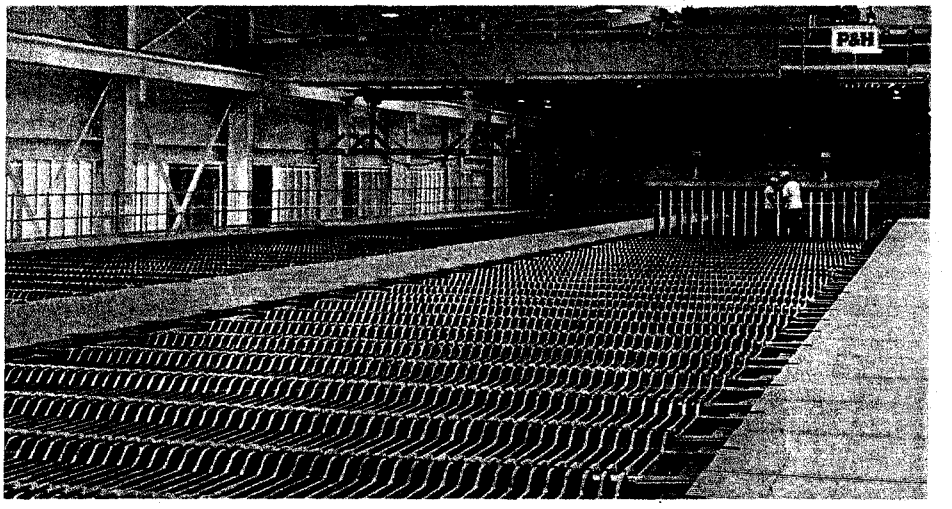
- Labor costs
- Capital costs
- Operating costs
- Environmental pollution.

In the mid-1980s, just as the domestic copper crunch was at its worst, Magma Copper Company began to apply leach/SX-EW because of its economies and minimal environmental effects. The result for Magma is that 26% of its production is done at costs that are about 40% lower than with traditional underground mining, smelting, and refining processes.

The Old Way

For a century most copper was produced by pyrometallurgical processes which entailed the high temperature oxidation of copper sulfide concentrates to first remove the iron, then the sulfur, and finally the purification of copper by electrorefining. In these processes, oxide ores were discarded along with other wastes.

Two of Magma's locations had previously used precipitation on iron scrap to recover limited amounts of copper from leach solutions resulting from sulfide waste leaching. However, the impure copper recovered still required conventional smelting and refining to produce a commercial grade product. In addition, the process was expensive.



Magma Copper's electrowinning operation is an electrochemical process that extracts high-purity copper metal from a copper rich electrolyte.

The New Way

The SX-EW process can treat copper sulfate solutions derived from leaching oxide ores and sulfide wastes. At Magma, four different leaching methods are used depending on the ore type.

Dump Leaching is usually carried out on waste rock piles, several hundred feet high, that result from open pit sulfide ore mining. This waste contains up to 0.25% copper, and, because it takes time to oxidize, the recovery is slow and usually less than 40% over a long period. Magma uses this process at its Pinto Valley operation.

Heap Leaching, or Pad Leaching, is done on a higher grade (+0.4% copper) oxide ore where the copper minerals are readily soluble in acid solution, giving over 70% recovery of the copper. Magma uses this process at its San Manuel open pit mine.

In Situ Leaching injects sulfuric acid solutions into "in place" orebodies that are difficult to mine economically by open pit or underground methods. Magma employs several in situ techniques very successfully at its San Manuel and Pinto Valley operations.

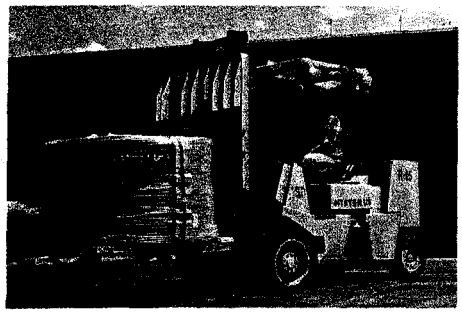
Hydraulic Mining/Leaching is employed where old waste dumps or tailings containing significant amounts of soluble copper are stockpiled. Magma utilizes hydraulic mining (slurrying with high-pressure water) at its Pinto Valley operations to mine these dumps and acidifies the slurry to dissolve the copper.

In the last decade, the technology of the chemical reagents used has

improved greatly. The result has been an increase in U.S. production from about 100,000 tons per annum of leach/SX-EW copper in 1980 to nearly 400,000 tons of high-grade copper in 1990 as more copper producers adopt this process.

In the SX-EW process copper is removed from the impure leach solutions by a very specific organic extractant which leaves impurities in the aqueous solution. Pure copper is then extracted with strong acid into the rich electrolyte from the electrowinning circuit.

The electrowinning process is physically similar to the electrorefining process except that it removes copper from the electrolyte—not the anode—and deposits it as a high-purity cathode. The major cost of the electrowinning process is for electric power, where consumption is about 1700 kWh per ton of copper deposited. An average of 500kWh are needed for pumping. Electrorefining, by comparison, requires just 300 kWh per ton; however, the overall process of leaching/SX-EW is much more economical.



This 5/16-inch wire rod produced from electrowon copper is one of Magma's principal products. The San Manuel plant has the capacity of about 180,000 tons per year of rod produced from electrowon and electrorefined copper.

Magma's copper operations receive electricity from both Arizona Public Service and the Salt River Project. The two utilities have joined with CMP to support several technical projects to make the leaching/SX-EW process even more efficient.

With Magma's current annual SX-EW copper production at 57,000 tons, electrowinning electricity usage per year totals almost 97,000,000 kWh.

The Results: Economical, Safe, Clean, Copper Recovery.

According to Michael A. Eamon, Superintendent–SX-EW, Magma's "costs per pound of copper are 39% lower when produced by open pit/in situ and SX-EW methods, compared with sulfide underground mining-through-refining steps." And he adds, "SX-EW is the final step...generally [producing] higher quality than electrorefined copper." Sulfide ore is mined–from either underground or open pit, milled, smelted, and electrorefined, while oxides involve open pit or in situ mining, leaching, and SX-EW. Summing up the differences, Eamon states: "A leaching/SX-EW operation is a much cleaner and more efficient method of producing copper."

SX-EW can be very safe environmentally, and avoids ground water contamination. Magma's San Manuel unit, for example, is a zero-discharge plant.

Heaps are placed on thick, impermeable, polyethylene liners to prevent fluids from leaking into the watershed.

The SX-EW process also eliminates the smelting phase of traditional processing. While new flash smelting operations oxidize the sulfur in copper concentrates and capture 98% of the sulfur dioxide, the systems still require special smelting equipment, as well as electrostatic precipitators, scrubbers, and related pollution control devices. Sulfuric acid produced at the smelter is used by Magma in its leaching/SX-EW operations.

The Bottom Line: A Reduced-Cost Operation that Helps to Maintain Competitiveness

Leach/SX-EW is a clean, low-cost method of producing high quality copper. It has reduced substantially the overall cost of copper production in the United States and made this country more competitive in world markets. Many U.S. copper operations have been able to survive and prosper only because of the introduction of these processes.

Summary of Advantages

Improved profitability. Significantly reduced capital, labor, and operating costs.

High purity. Copper is ready for casting or sale without further refining.

Efficient. Overall energy savings compared with traditional sulfide processing.

Low maintenance. Smooth running operations with reduced personnel requirements.

Safer. Employee safety is improved through the elimination of labor intensive and high-risk processes.

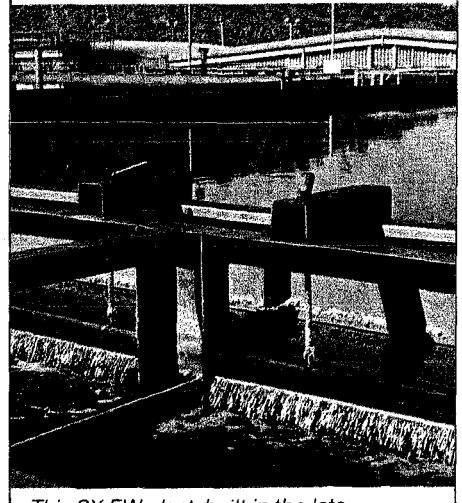
Zero discharge. Environmentally neutral processing, so air and land stay cleaner without costly pollution control equipment.

Value from waste. High-purity copper from often already-mined resources normally discarded.

COMPANY PROFILE

Magma Copper Company was established in 1910 on the site of Arizona's Silver Queen Mine, in operation since the 1870s. The San Manuel claims were purchased in the 1940s and additional exploration and drilling began; in the early 1950s, the San Manuel mine and smelter were started. Then, in 1969, Magma merged with Newmont Mining Corporation. In 1972, electrorefined cathode and rod production began at San Manuel. The 1986, open pit mining and leach/SX-EW were started, and Pinto Valley was acquired as an operating division. In situ leaching began in 1987, the same year Magma was spun off by Newmont.

Today Magma employs nearly 4,300 people at its three locations and processes nearly all of its copper as continuously cast rod. The rod is feedstock for the wire drawing industry to produce telecommunications wire and cable, power transmission/distribution cable, and magnetic, building and automotive wire.



This SX-EW plant, built in the late 1980s, is located at the San Manuel mine site which has been in operation for nearly forty years. Here, copper leached from oxide ore is transferred by solvent-extraction to copper-rich electrolyte for electrowinning.

For further information contact:
CMP Mining and Minerals Processing Office,
P.O.B. 2740, Evergreen, Colorado 80439
TEL: 303-980-9978 FAX: 303-670-0976

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The EPRI Center for Materials Production

Carnegie Mellon Research Institute
4400 Fifth Avenue
Pittsburgh, PA 15213-2683
412-268-3243