

**CURRENT EQUIPMENT DESIGN IN COPPER SOLVENT EXTRACTION PLANTS**

**By**

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1. INTRODUCTION

One of the most interesting current developments in non-ferrous extractive metallurgy is the application of solvent extraction - electro-winning techniques to the recovery of copper from low-grade leach solutions. This application of solvent extraction in extractive metallurgy represents a breakthrough, since previously the use of this technique had been confined to the higher-priced metals, mainly those used in the nuclear field. The plants used were relatively small-scale, and the product value was high. In the case of copper, the product value is relatively low and the flow rates of solution in the plant are high. Because of these conditions, the philosophy used in the design of the copper solvent extraction plants is somewhat different from that used in the earlier plants. This paper briefly discusses some of the recent innovations in equipment design.

2. CHOICE OF CONTACTOR

At present there are four commercial solvent extraction-electro-winning plants operating in the U. S. A. (1-7). These

plants all use the chelating extractant known as LIX64N, manufactured by General Mills, Inc. This reagent is a more or less specific extractant for copper under acidic conditions. The American plants are all relatively small-scale, each producing 40,000 lbs. Cu/day, or less, with feed solution flow rates to the solvent extraction section of less than 1,000 gal/min. However, there is, under construction at the present time, a plant at Chingola in Zambia which is an order of magnitude bigger. It is scheduled to produce in excess of 450,000 lbs. Cu/day with a leach liquor throughput of 12,000 gal/min. (8).

All these plants use or will use mixer-settlers in the solvent extraction section. Mixer-settlers suffer from a major disadvantage compared with other contactors, such as the various types of column contactors available, in that they have a very large solution hold-up volume. LIX64N is an expensive reagent which sells at U.S. \$2.50 per lb. and so the solvent inventory in these plants comprises a very significant proportion of the capital cost of the plant. In the case of the Zambian plant, the mixer-settlers plus their initial solvent fill are said to account for almost 40% of the equipment cost of the plant (9). The question then arises as to why mixer-settlers are preferred over the many other types of contactor that are available which have much smaller solvent inventory requirements. There are several reasons for this. One is that the rate of extraction of copper by LIX64N is quite slow, compared with extraction rates common in other solvent extraction systems. The rate varies with the pH of the aqueous phase (10) but, in general, a mixing time

of at least 2 minutes is required to achieve equilibrium of the phases. This puts a serious limitation on the use of column extractors for this system. However, undoubtedly the major reason for the choice of mixer-settlers is that they are the most reliable type of contactor available. They are flexible in operation, changes in flow rate can be accommodated and extreme phase ratios can be handled by recycling within the cascade, this being a relatively simple matter. This means that these contactors are well able to cope with upset or changing process conditions. An investment on the scale of the Zambian plant, which will be of the order of U.S. \$45 million (8), cannot be put at risk through the use of more sophisticated but less flexible contactors. Another factor which led to the choice of mixer-settlers is the phenomenon known as crud formation. Crud is an indeterminate solid material of both organic and inorganic origin which collects at the organic-aqueous interface in the settler. It is a combination of fungal and bacterial growth together with very fine solid particles which enter the plant in the leach liquor. The extent of crud formation is unpredictable and can only really be known when the plant is in operation. The design of a mixer-settler lends itself to the removal of crud, by physical means, from the interface in the settler.

### 3. MIXER SETTLER DESIGN IMPROVEMENTS

The commitment to the use of large scale mixer-settlers has led to an intensive program of development to optimise the design of this type of equipment. Here again, the physical

nature of a mixer-settler facilitates optimisation since the mixing and settling functions are separate and can thus, to a degree, be optimised independently. Most of the development work has been carried out by the Power Gas Corporation Ltd. U. K. (11, 12) who are the contractors responsible for the design of the Zambian plant. The two major objectives of the optimisation program were to minimise (a) the settler area requirements, since the hold-up volume in the settlers accounts for the major proportion of the total solvent inventory, and (b) the loss of solvent caused by entrainment in the raffinate leaving the plant.

The design of the mixer affects both (a) and (b) since they are both dependent on the droplet size produced in the mixer. Very fine droplets require long settling times which lead to large settler area requirements or alternatively to increased entrainment losses. The Power Gas mixer-settler involves the use of multiple mixers associated with each settler in order to obtain high throughputs without the difficulties associated with very large mixers. The impellers used are of a double-shrouded backward swept vane design. This design leads to low shear rates and thus minimises the production of very fine droplets. In addition to its mixing function, the impeller acts also as a pump to raise the mixed phases to a level from which they can flow into the settler under gravity. The pumping action is achieved by having a draught tube below the impeller.

Improvements in settler design include the use of a full-width baffle on the settler inlet which is designed to feed the mixed phases directly into the dispersion band at the coalescing

interface. This baffle eliminates turbulence and re-entrainment of the phases in the region of the settler inlet. Another improvement is the use of picket fence baffles placed across the width of the settler at intervals along its length. These damp out wave motions, which can occur in the settler and which can lead to aqueous or organic carryover at the outlet weirs, and also maintain a regular flow pattern in the settler.

Although careful design of the mixer and the settler can minimise the loss of organic phase by entrainment in the raffinate, it is generally economic to instal some form of equipment to recover organic material from the raffinate. This can take the form of centrifuges, coalescing beds, or flotation cells. Coalescing beds, where the solution is passed through packed filaments of glass fibre or similar material, are very effective in promoting coalescence of the entrained droplets of organic. However, in practice they suffer from the disadvantage of easy blockage due to the presence of particles of solid material and crud in the raffinate, leading to the necessity for frequent cartridge changes. Work by the Power Gas Corporation has shown that, in general, flotation cells are a more economic solution. Standard mineral dressing flotation cells can be used and no flotation reagents are required. The use of this type of equipment means that the mixer-settlers can be operated with a higher throughput and also there is then a safeguard against loss of the valuable organic due to a massive carryover which could follow a malfunction in the solvent extraction section.

#### 4. FUTURE DEVELOPMENTS

At present the design philosophy used for these large solvent extraction plants is one governed by the necessity of achieving maximum simplicity and foolproof operation. As experience is gained in the operation of these plants there is no doubt that more sophisticated equipment will be used in the future. One improvement which may well be used, if conditions permit, is the use of coalescing aids in the settler. For example, multiple-layer horizontal baffles, which provide multi-layer settling, can increase the effective settler area several times. Another possibility is the use of column contactors for stripping the organic. Although the extraction kinetics of LIX64N are relatively slow, the reverse reaction, that of stripping, is much faster (10), and it may be possible to carry this reaction out in column contactors and thus reduce the total solvent inventory of the plant.

Finally there is the possibility of using a different reagent. KELEX 100, manufactured by Ashland Chemicals, extracts copper under conditions similar to LIX64N, but it has been shown to have both better loading characteristics and faster extraction kinetics than LIX (10, 13). With this reagent it may be possible to design a complete plant using column contactors. This should result in a considerable saving in solvent inventory, thus reducing the capital cost of the plant.

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