OPERATION OF A FLOTTWEG TRICANTER® CENTRIFUGE FOR CRUD TREATMENT AT BWANA MKUBWA SOLVENT-EXTRACTION PLANT

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ABSTRACT

Bwana Mkubwa is a 50 000 tons per annum copper cathode producer, owned by First Quantum Minerals and located in Ndola, on the Zambian Copperbelt. The Bwana Mkubwa solvent-extraction circuit was started up in 1997. In 2002, the plant began treating ore from First Quantum's Lonshi mine located in the Democratic Republic of Congo. Lonshi ore is exceptionally fine and the amount of solids in the feed solution reporting to the solvent-extraction circuit increased dramatically. Initially, crud was filtered in a filter press, but this rapidly blinded and seldom produced anything better than a wet sludge containing large quantities of organic. In December 2003 the decision was made to install a Flottweg Z4E-3/441 Tricanter® centrifuge to recover organic from the crud. The installation was completed in June 2004 and has since led to significant improvements in plant operability and savings in organic consumption. A case study of a three year operational period of the Tricanter is presented.

INTRODUCTION

Bwana Mkubwa Mine Site (BMMS) is an agitation leach plant that treats ore from the Lonshi mine in the Democratic Republic of Congo (DRC). The ore is trucked to the plant site outside Ndola, where it is crushed, milled and leached to solubilise the copper. Liquid/solid separation takes place in a counter-current decantation (CCD) system. Pregnant leach solution (PLS) is clarified using two Bateman pinned-bed clarifiers, after which it is pumped to solvent extraction (SX), where copper is recovered using LIX® 984N in a hydrocarbon diluent. Figure 1 shows a schematic diagram of the flow arrangement at Bwana Mkubwa.

Lonshi ore, with a d_{50} of around 23 μm, contains large amounts of fine solids making solid/liquid separation difficult. Even with the pinned-bed clarifiers the exiting PLS contains some fine solids. The solids enhance crud formation in the SX settlers and reduce phase separation capacity.

As production levels increased, crud treatment became an important process in BMMS SX operations. Continuous removal of crud and its treatment was required to ensure undisturbed SX operations. The former mitigates incidences of crud movement; the latter ensures quick return of organic to the circuit and minimises organic losses associated with crud disposal following treatment.

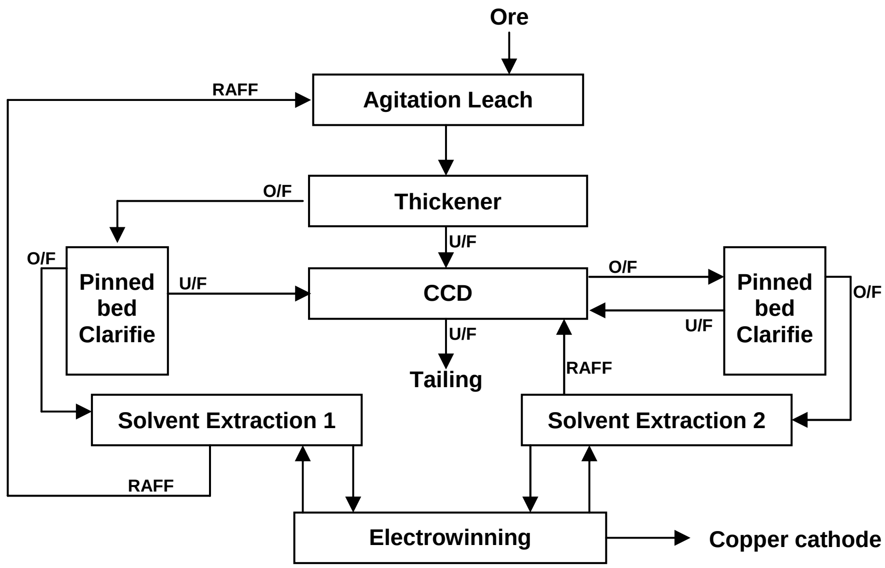

Figure 1. Bwana Mkubwa process flowsheet.

Crud treatment using a filter press at BMMS has significant disadvantages, detailed below.

- **Slow Treatment Rate:** Poor filterability of crud resulted in extremely slow filtration rates compounded by high cycle rates presenting a bottleneck to crud removal and resulted in frequent crud movements. Periodic emptying of settlers to clean out crud reduced SX plant utilization.
- **High Treatment Costs:** Filter cloth cost US$ 12,000 per month. Washing of the filter and cake disposal required between required 20 to 30 man hours per day. Precoating with filter aid was necessary to get any form of performance out of the filter press, which added to the labour requirement, operating costs and waste disposal problems.
- **High Organic Losses:** Table 1 shows an analysis of organic losses in the filter press 'cake'. The loss of organic was calculated on the basis of a filter press solids catchment tray volume of 1.8 m^3, 24 % LIX 984N and disposal rate of 1.5 trays per day.

Table 1. Analysis and cost evaluation of organic lost in crud disposal

Composition	Organic	Crud	Aqueous
Proportion vol.%	27.3	57.6	15.6
Proportion t/tray	0.4	1.4	0.3
US$/tray	1,100	-	-
US$/day	1,650	-	-

INSTALLATION OF A FLOTTWEG TRICANTER CENTRIFUGE

Based on the successful use of the Flottweg Tricanter® for crud treatment at various copper SX plants in Chile, as well as at KCM in Chingola, Zambia, it was proposed that this technique be used at BMMS. The unit was installed in June 2004.

Mode of Operation

The Tricanter is a horizontal, solid bowl, decanter centrifuge. The feed is separated into a light liquid phase (organic), a heavy liquid phase (aqueous) and a solid phase (crud). The discharge of the separated organic is done by gravity, while the separated aqueous phase is discharged by an impeller under pressure.

The separated solids are conveyed by the scroll to the conical end of the bowl and are discharged. A variable speed drive permits changes in the rate at which the crud is removed, maximising the removal of organic solution from the crud.

A movable weir ensures accurate control over the phase separation, allowing operators to adjust for process fluctuations while the machine is in operation. This is a critical aspect in the use of centrifuges for crud treatment as the composition of crud is highly variable.

Typically the crud discharged from the Tricanter is a slightly damp granular solid, with in excess of 95% of the organic having been recovered. A feedback control loop ensures that the machine is never overloaded with solids. The torque on the scroll is monitored, and when it rises above a set point, the control loop speeds up the scroll to discharge the solids faster, and at the same time slows down the feed pump to reduce the solids load. This allows the machine to absorb significant variances in feed consistency. The organic recovered proved to be free of residual solids.

The Presence of a 4^{th} Phase in the Crud

At the time of commissioning it became evident that the aqueous discharge contained significant amounts of solids, giving it the appearance of mud. It was then noted that the Tricanter experienced intermittent blockages in the heavy phase discharge port and occasional breakthrough of solids to the organic phase. During investigation of the problem by Flottweg's service agent, Centrifuge Technology Services, it became evident that the crud did not consist of three phases but that, even after centrifugation, a 4^{th} phase existed between the aqueous and organic phases. The phase is made up of ultra-fine solid particles, and is very stable. Minor adjustments to the operation of the centrifuge resolved the problem of discharge port blockages.

The 4^{th} phase does, however, present a peculiar problem as three-phase separating centrifuges are simply not designed to separate 4 phases. It is essential that the 4^{th} phase be discharged as it would otherwise lead to rapid blocking of the entire machine. It is also not desirable to have this phase discharged with the organic phase as the significant amounts of ultra fine-solids would cause further crud problems in the SX system.

The only option remaining is for the solids to be discharged with the aqueous phase. To achieve this it is not only essential that the centrifuge be equipped with an adjustable weir to give precise control over the pond depth of the aqueous and organic phases within the machine, but this weir also has to be in contact with both the aqueous phase and the 4th phase.

The significance of the 4th phase to crud treatment cannot be overemphasised. Flottweg has tested numerous crud samples from all around the world and has found that virtually all of these contain a 4th phase. While little is know about the composition of the 4th phase, other than that it has been associated with clay-containing ores, the 4th phase becomes more prevalent with increased flocculant additions in the CCD circuit. When planning a crud treatment system utilizing centrifuges – in particular where no pilot studies have been carried out on the crud - engineers will have to design for crud with 4 phases. They will need to be certain to choose not just a three-phase separating centrifuge, but one designed to deal with a 4th phase.

ECONOMIC ANALYSIS OF CENTRIFUGE INSTALLATION

Organic Consumption - Before and after the Tricanter Centrifuge Installation

Before the treatment of the Lonshi ore began, extractant consumption was typically less than 2 kg/t of copper at Bwana Mkubwa. With the start of Lonshi ore treatment, extract consumption was variable, but increased to above 3.5 kg/t before the centrifuge installation in June 2004 and it now averages below 3.0 kg/t (Figure 2). This has resulted in savings of over US$ 50,000 per month.

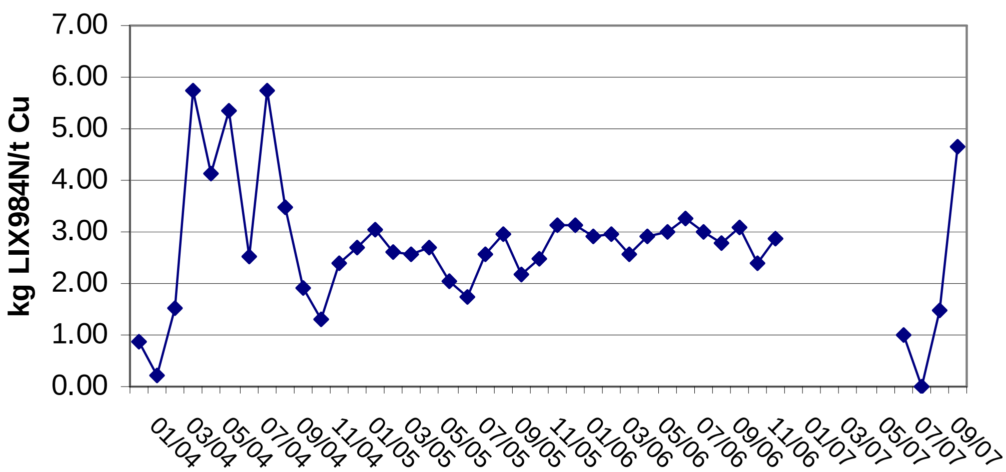

Figure 2. Extractant consumption at BMMS 2004 – 2006.

At the same time that extractant consumption was reduced, changes were made to the configuration of the SX circuit. The low-grade SX wash stage was converted to a parallel extraction stage. From time to time, the high-grade wash stage is also used a parallel stage for the recovery of copper from dam return solution. These changes would usually be expected to double the extractant consumption, but consumption was significantly reduced by use of the centrifuge.

SX Plant Downtime - Before and After the Tricanter Centrifuge Installation

Before installation of the centrifuge, settlers were emptied every 8 months on a rotational basis for cleaning because there was a build up of crud which the press filter could not cope with. Since the installation of the centrifuge, removal of crud is done online and this has resulted in increased SX plant utilisation (Figure 3).

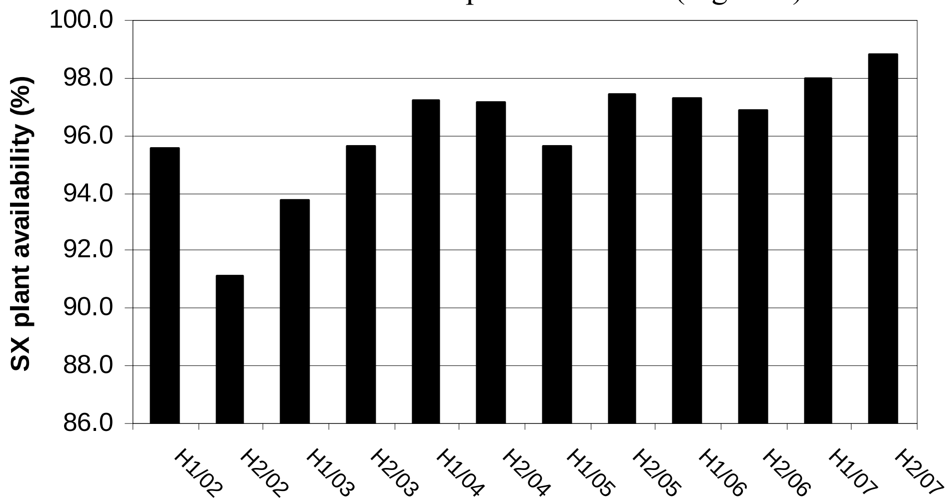

Figure 3. BMMS SX plant availability.

The bulk of ore mined at Lonshi produces fine material which cause such severe crud generation, that it was generally not possible to operate the SX plant when the PLS was derived from this material alone. A proportion of the more rocky ore would have to be fed to the leach circuit at the same time. Failure to do this would at times result in severe crud runs, one of which brought the SX plant operation to a standstill for 6 days. As the rocky material was not always available, the logistics of feeding the leach section were quite complicated. Since the installation of the Tricanter no crud runs have occurred and it has been feasible to operate the plant on a feed of only Lonshi ore for periods in excess of 9 months. This has significantly simplified the control of feed to the leach section

Maintenance Costs on the Tricanter

To ensure extended life and optimum performance of the machine, about US$ 20 000 has been spent per annum on annual planned maintenance. It also includes regular site visits from Centrifuge Technology Services – the appointed service agent for Flottweg centrifuges. The training and technical support from CTS has been key to the success of this machine. The cost of maintenance has proved insignificant on the basis of US$/kg of copper produced.

Labour Requirement - Before and After the Tricanter Centrifuge Installation

Unlike a filter-based crud treatment system which required 20 to 30 man hours per day, the centrifuge only required 1 to 2 man hours per day. The centrifuge is set up according to the nature of the feed, and then occasional checks are made to make sure that no major change in the feed consistency has occurred. After treating a batch of crud the machine is flushed with water.

Clay Treatment

At the time the centrifuge installation was planned it was not considered for use in clay treatment of recovered organic. Subsequent test work to use the centrifuge to remove clay from the organic after clay treatment proved successful. The weir is simply adjusted to ensure that all of the liquid is discharged from the light phase port. In this manner two-phase separation is made possible. Flow rates during clay treatment are about 25 % higher than during crud treatment

CONCLUSIONS

a) Use of a Flottweg Tricanter centrifuge at Bwana Mkubwa has significantly reduced organic losses by approximately US$ 50,000 per month.
b) More efficient operation of SX plants has been achieved due to ability to continuously remove crud.
c) Crud treatment is now fast and allows quick return of organic to the SX circuit.
d) Instances of crud movement have been eliminated.
e) These improvements to the SX operation have had significant financial and process advantages.
f) The presence of a 4th phase in SX crud needs to be considered when selecting a centrifuge for crud treatment applications.

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