A CASE STUDY ON THE OPERATION OF A FLOTTWEG TRICANTER® CENTRIFUGE FOR SOLVENT-EXTRACTION CRUD TREATMENT AT BWANA MKUBWA, NDOLA, ZAMBIA

by

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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. The Lonshi ore is exceptionally fine and the amount of solids in the feed solution reporting to the solvent-extraction feed solution 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.

1. INTRODUCTION

Most commercial solvent-extraction plants suffer from the formation of crud. Crud is a solid-stabilised emulsion which most commonly accumulates at the aqueous/organic interface in the settlers of solvent-extraction stages. It is caused by a variety of substances entering the SX circuit, ranging from wind-blown dust, entrained solids from the leaching, impurities in the plant solutions, and even insects attracted by the lights in the solvent-extraction plant. While a thin layer of crud at the aqueous/organic interface can aid coalescence of fine droplets, excess crud can interfere with phase separation and severely reduce the efficiency of the settlers.

If allowed to build up in the settlers, crud can start moving to the next mixing stage. This can rapidly cause a 'crud run' resulting in severely increased entrainment, causing contamination of electrolyte with leach solution and organic phase. The transfer of organic to the electrowinning can cause 'cathode burn'. The entrainment of electrolyte into the extraction section of the solvent extraction can result in loss of copper to the raffinate. Entrainment of organic in the raffinate will result in increased organic losses. While removal of crud from solvent-extraction plants does not usually pose a major problem, crud typically has an organic content in excess of 50% and losses of organic with the crud can cost plants from hundreds of thousands to millions of dollars per annum.

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 system (CCD). 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.

The Lonshi ore contains large amounts of very fine solids. Solid/liquid separation is extremely difficult and even with the pinned-bed clarifiers, the PLS contains some fine solids. These solids enhance the formation of crud in the SX settlers and reduce phase separation capacity [(1)].

Prior to the installation of the Flottweg Tricanter centrifuge at Bwana Mkubwa, crud was treated in a plate-and-frame filter press (see Figures 2 & 3). This paper describes the installation and performance of the Tricanter at BMMS in Ndola, Zambia, since its installation in 2004[(2,3)]. 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[(4)].

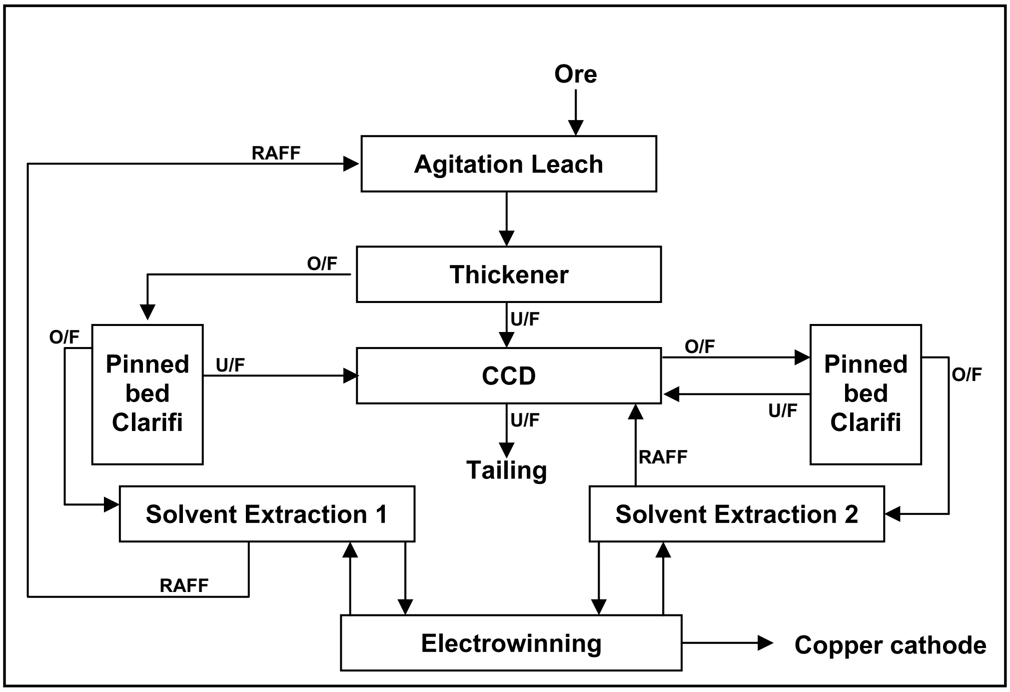

Figure 1: Bwana Mkubwa process flowsheet.

Figures 2 and 3: Crud filtration at BMMS, using plate-and-frame filter press.

Crud treatment using a filter press at BMMS had significant disadvantages, which are detailed below.

Slow Treatment Rate: Poor filterability of crud resulted in extremely slow filtration rates compounded by high cycle rates. This presented a bottleneck to crud removal and resulted in frequent crud movements. SX plant utilization was also low because settlers were periodically emptied to clean out crud and this sometimes resulted in prolonged shutdowns due to low organic inventory.

High Treatment Costs: Filter cloth usage, at four sets per month, was equivalent to US$ 12,000 per month. Press filter operations are labour intensive. Washing and cake disposal required between required 20 to 30 man hours per day.

Precoat Costs: To get any form of performance out of the filter press, the cloths had to be precoated with filter aid. This 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. A sample of the filter press cake is shown in Figure 4.

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	-	-

**This organic loss was calculated for a tray volume of 1.8 m^3 with a disposal rate of 1.5 trays per day.*

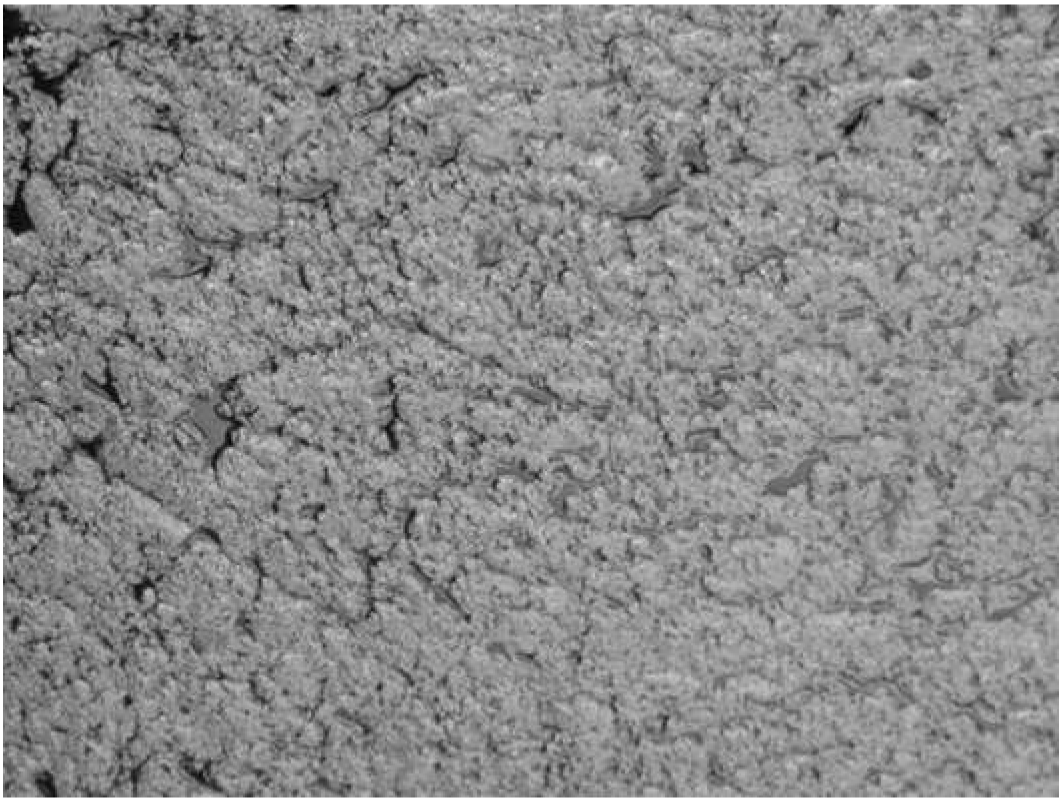

Figure 4: Crud 'cake' discharged from filter press

2. INSTALLATION OF A FLOTTWEG TRICANTER CENTRIFUGE

The Flottweg Tricanter provides an efficient, reliable system for recovering clean organic from crud. Crud removed from the settlers is fed to the Tricanter, which removes the crud, as well as the entrained aqueous solution, to return clean organic solution to the process. The strength of the Tricanter is its ability to recover virtually all of the organic entrained in the crud.

Based on the successful use of the Flottweg Tricanter for crud treatment at some of the copper SX plants in Chile, as well as at KCM in Chingola, Zambia, it was proposed that this technique be used at BMMS. The SX plants in Chile typically generate much less crud than the SX plants in Zambia. The Chilean plants treat PLS from a heap leach, while the Zambian plants operate agitation leach on milled ore. Obviously the PLS from agitation leaching of milled ore contains many more fine particles than heap leach PLS.

2.1 Mode of operation

The Tricanter is a horizontal, solid bowl, decanter centrifuge. In a Tricanter 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 (Figure 5)[(5)].

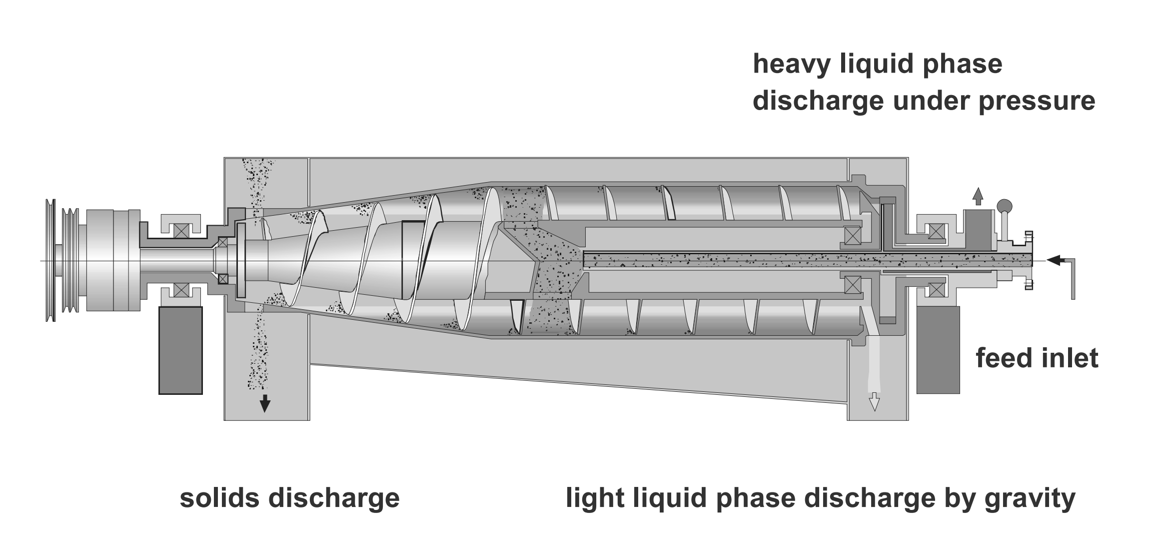

Figure 5: Cross-section of a Flottweg Tricanter centrifuge.

A movable weir ensures accurate control over the phase separation, allowing operators to adjust for process fluctuations while the machine is in operation. 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 from the crud. Typically the crud discharged in this manner is a slightly damp granular solid, with in excess of 95% of the organic having been recovered (See Figure 6).

Figure 6: BMMS Tricanter centrifuge solids discharge

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 by the Tricanter proved to be free of residual solids (see Figure 7).

Figure 7: BMMS Tricanter centrifuge organic discharge.

3. ECONOMIC ANALYSIS OF CENTRIFUGE INSTALLATION

3.1. Organic consumption - before and after the installation of the Tricanter centrifuge

Before the treatment of the Lonshi ore began, extractant consumption was typically less than 2 kg/t at Bwana Mkubwa. With the start of Lonshi ore treatment, extract consumption was variable, but increased to above 3.5 kg/t before centrifuge installation in June 2004 and now it is averaging below 3.0 kg/t (Figure 8). This has resulted in savings of over US$ 50,000 per month.

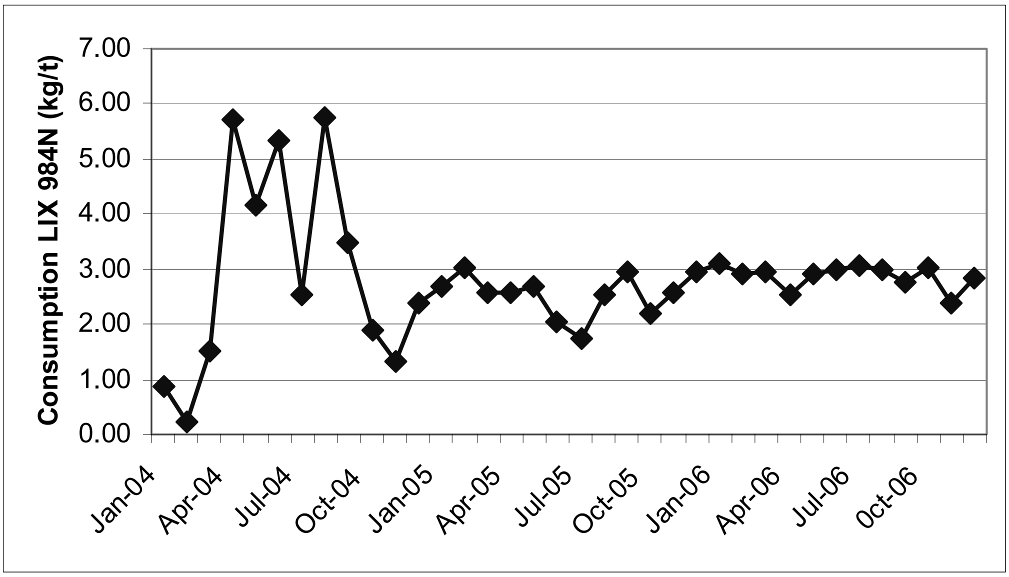

Figure 8: Extractant consumption at BMMS 2004 – 2006.

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.

3.2. Downtime on the SX plant - before and after the installation of the Tricanter centrifuge

Before installation of the Tricanter 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 9).

The bulk of ore mined at Lonshi ore produces very fine material which causes such severe crud generation, that it was generally not possible to operate the SX plant when the PLS was derived from 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 entire SX plant 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

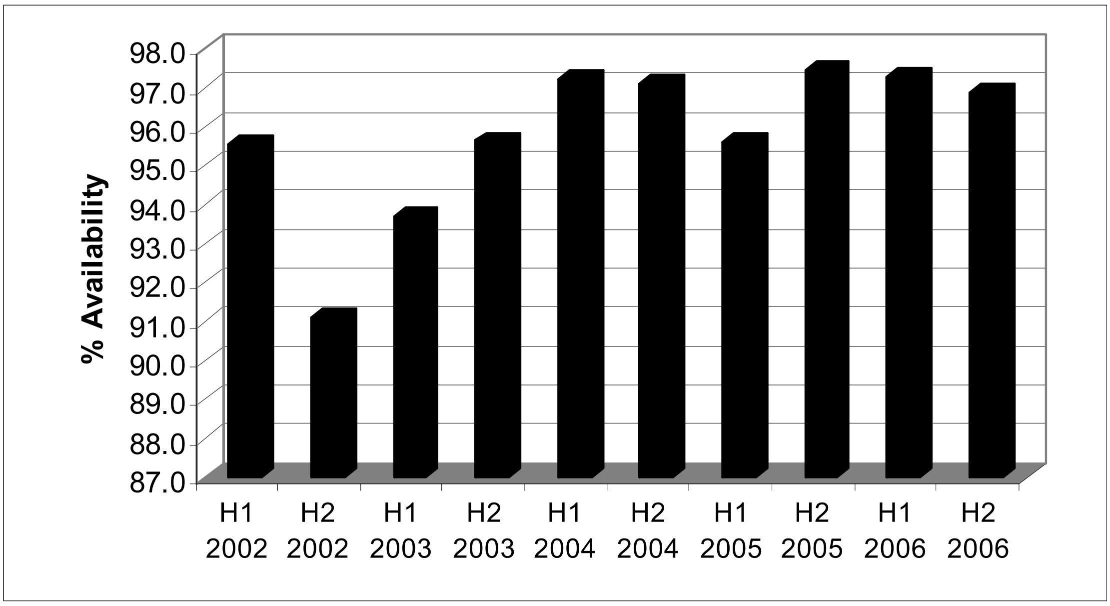

Figure 9: BMMS SX plant availability.

3.3. 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. This cost comes in form of bearings and O-ring replacement as well as all regular service items for the unit. It also includes one site visit from Centrifuge Technology Services – the appointed service agent for Flottweg centrifuges. The service delivery from CTS has been exceptional and must be made use of to get full benefit from the machine. 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.

3.4. Labour requirement - before and after the installation of the Tricanter

Unlike the conventional 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.

3.5. Clay treatment

At the time the centrifuge installation was planned, it was not considered for use in clay treatment of recovered organic. Subsequent testwork to use the centrifuge to remove clay from the organic after clay treatment proved very 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 those during crud treatment

4. OPERATIONAL ISSUES

The Tricanter centrifuge is a high-speed machine requiring good maintenance and operational practice.

a) Greasing: Daily greasing is recommended and this is done manually as the machine does not come with the optional automatic lubrication system. In hindsight an automatic greasing system would have been ideal as it would ensure consistant greasing quantity and frequency.
b) Continuous Operation: Continuous operation is recommended to extend the life of the bearings. The feed to the Tricanter can be adjusted to ensure continuous operation.
c) Feed Filtration: A strainer is recommended on the feed line to prevent foreign solids like stones, wood-chips, mine waste, etc., from getting into the centrifuge.

5. 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.

6. REFERENCES

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