Crud Forx™ - A New Approach to Crud Management

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Operational challenges associated with solvent extraction (SX) plants include the effective on-line management of solids introduced from a variety of process streams. Solids are carried over from leaching circuits due to incomplete solid–liquid separation, may be formed as a result of chemical precipitation within the SX circuits, or introduced from downstream electrowinning operations. Solids in SX settlers result in operational challenges that impact plant availability and reduce optimized name-plate design capacity operation. Most available SX crud and bottom solids removal systems are limited in their effectiveness to handle high total suspended solids in SX circuits. Operations are often forced to take settlers off-line for complete removal of contained solids. These cleaning operations are hazardous, high risk, labour-intensive and costly in terms of production down-time and organic extractant and diluent reagent losses. Production pressure results in operations being reluctant to take SX settler units off-line for solids clean-out, resulting in continued operation of the SX, at reduced levels of mass transfer performance. Crud Forx™ is an SX solids removal system, for the on-line removal of interfacial and bottom solids associated with hydrometallurgical SX processes. A case study conducted at Glencore's Mutanda Mining copper and cobalt operation in the Democratic Republic of Congo demonstrated the effectiveness of the Crud Forx. Benefits identified were an overall improvement in SX fire risk reduction, SX occupational health and safety and an improvement in copper mass transfer.

INTRODUCTION

Hydrometallurgical copper extraction and purification processes are often associated with ultra-fine solids distribution profiles throughout the process flowsheet (Virnig et al., 1999). The level and impact of the undesired deportment of solids to process streams varies from operation to operation, but the common denominator for all operations that employ solvent extraction (SX) as a copper upgrading and purification step is that, at some stage, they will have to manage solids (crud) within the SX circuit. Available crud removal systems in the industry have had limited success in continuous, effective interfacial crud and bottom solids removal from SX settlers. Most operations use basic removal methodologies which, at best, only result in delaying the requirement for taking the affected SX settler stages off-line for complete clean-out. This operational methodology results in production loss, increased SX organic extractant consumption and adds occupational health and safety risk to SX operations. The integrated Crud Forx™/Crud Frogz™ SX solids management system assists operations in on-line SX solids management. The system has been proven to significantly reduce the requirement for off-line cleaning of settlers.

INTEGRATED CRUD FORX™ AND CRUD FROGZ™ DEFINED

Figure 1 shows the Crud Forx which is designed to target settler bottom solids. The Crud Forx can be used independently or in tandem with the Crud Frogz (Figure 2). The Crud Frogz is designed to manage interface crud in SX settlers. The component systems are adaptable to most SX settler design applications and require a minimum of auxiliary services, all of which are typically included as part of standard SX industry installations. Materials of construction are selected based on process-specific operating conditions. The Crud Forx system consists of a multiple-piped slurry suction head that can be connected directly to a removable flexible hose coupling (for settler side solids removal) or to one or more modular lengths of rigid transfer piping (for accessing areas further in the body of the settler). The compact nature of the system allows for easy adaptation for most applications in SX settlers and can be readily tailored to process-specific requirements.

Figure 1. Crud Forx™ system.

Figure 2. Crud Frogz™ system.

The Crud Frogz consists of a tripod-mounted crud suction chute, custom-dimensioned to SX settler operating organic–aqueous interface height. The Crud Frogz can also be connected directly to a removable flexible hose coupling (for settler side interface solids removal) or to one or more modular lengths of rigid transfer piping (for accessing areas further within the body of the settler). These applications are illustrated in Figures 3 and 4.

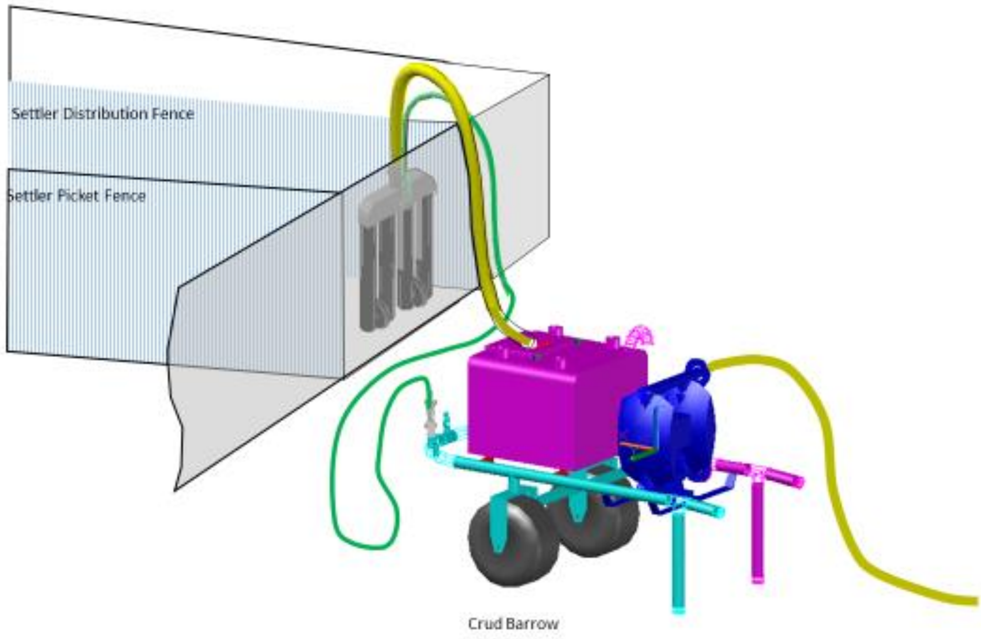


Figure 3. Crud Forx™ settler side application.

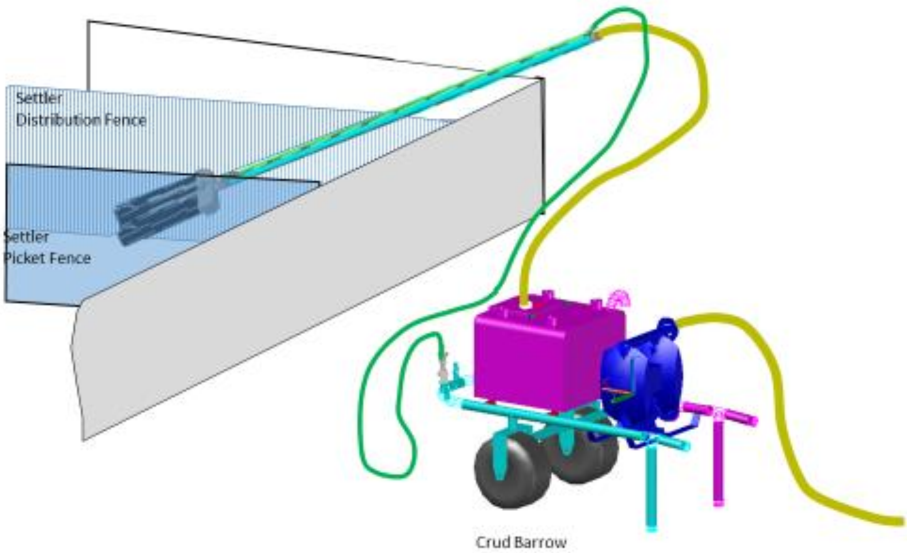


Figure 4. Crud Forx™ Settler body application.

Note: The integrated system rigid piping and coupling systems are inter-changeable for both the Crud Forx and Crud Frogz units.

The Crud Forx uses a unique combination of fluid "lift" and "back-pulsation" technology that ensures SX settler bottom solids removal and solids mobilization is extended beyond the immediate deployment zone of the unit. The motive fluid employed is low-pressure plant compressed air. The transfer mechanism results in a high solids content, low organic content slurry, that can be pumped to downstream crud treatment operations. The high solids content of the removed slurry often results in a debottlenecking of installed crud treatment facilities due to lower volumetric throughput requirement to treat similar masses of removed solids. Table I shows a typical composition of Crud Forx-removed bottom solids slurry for a targeted zone in a copper SX settler. The distribution of organic, aqueous and solids is shown for slurry removed at the beginning of an application cycle (left measuring cylinder in the image insert) and at the end of the application cycle (right measuring cylinder in the image insert).

Table I. Typical Crud Forx-removed bottom solids slurry composition – copper SX.

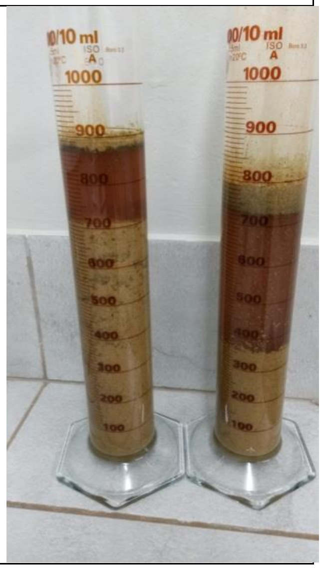
Phase	Typical slurry composition (free-settled volume %)			
	Application cycle start	Application cycle end	Application cycle average	
Bottom solids	79.7	47.9	28.6	
Aqueous	19.1	50.7	68.1	
Surface organic	1.1	1.4	3.3	
Slurry density	1.097	1.087	1.09	
Mass % solids	26.3	14.9	26.1	

Figure 5 shows a typical Crud Forx bottom solids slurry discharging into a crud barrow system used to pump the recovered bottom solids slurry to the crud treatment unit operations.

Figure 5. Typical Crud Forx bottom solids slurry discharge into crud barrow.

The Crud Frogz system is designed to be connected to existing crud-removal positive displacement pumping system infrastructure. The unit is customized to operate at the SX settlers design-optimum organic–aqueous interface operating height. The suction chute of the Crud Frogz allows for interfacial crud removal, targeting within a zone on either side of this optimum height to allow for process fluctuations. The Crud Frogz suction piping is fitted with an inspection sight-glass which allows the operator to monitor interfacial crud removal more effectively. This results in less co-removed organic and aqueous per volume of interfacial crud solids removed.

CRUD FORX BOTTOM SOLIDS PROFILE COMPARISON

Figures 6 and 7 show the bottom solids profile of an operational settler before and after 8 hours of Crud Forx application. Approximately 24 vol% of bottom solids removal was achieved in the 8-hour application period.

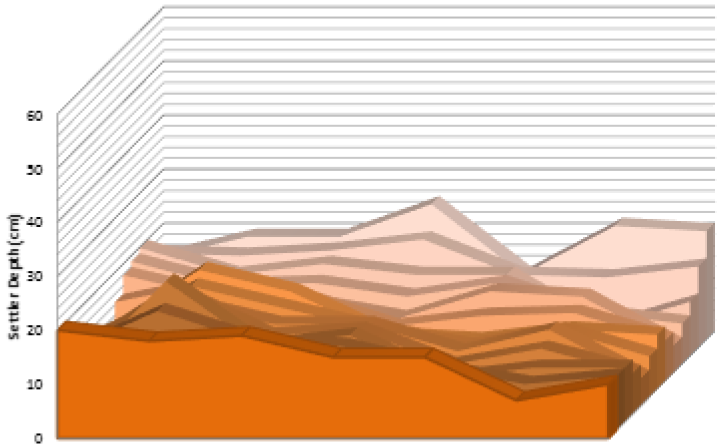


Figure 6. Settler bottom solids profile before Crud Forx application.

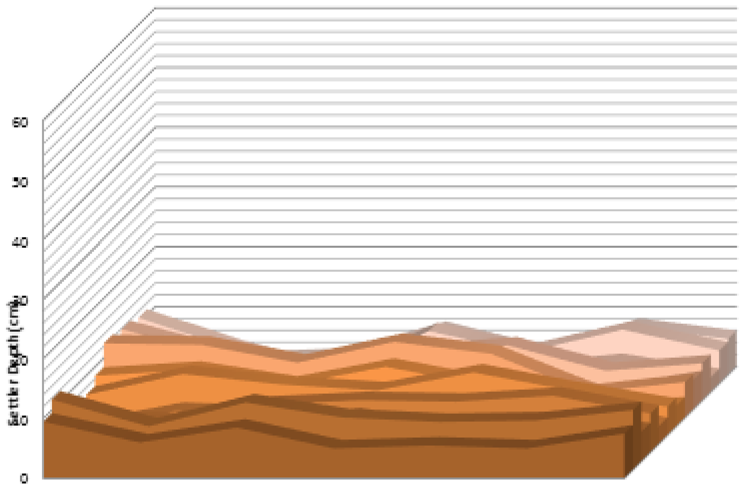


Figure 7. Settler bottom solids profile after Crud Forx application (after 8 hours of application)

CASE STUDY MUTANDA MINING SARL, GLENCORE 2014

Mutanda Mining SARL, Glencore

Overview

Mutanda Mining SARL is situated approximately 40 km southeast of Kolwezi in the Katanga Province, Democratic Republic of Congo. The combined nameplate capacity of the hydrometallurgical processing circuits is 200 ktpa of copper cathode and 1.7 ktpa of cobalt intermediate product. The hydrometallurgy circuits consist of three parallel mill, agitation leach and thickener-CCD (counter-current decantation) trains that produce high-grade (HG) and low-grade (LG) pregnant leach solutions (PLS) which feed five SX circuits. The advance electrolytes from the five SX circuits are distributed to seven EW tankhouse complexes. The intermediate cobalt product is derived from a bleed stream of LG raffinate, which is processed via the cobalt purification, filtration and product-drying circuit. A feature of the Mutanda operation is the high level of flexibility that has been included in the installed plant. This allows the operation to configure the circuits for optimum copper mass transfer, plant availability and utilization.

SX Operational Challenges

Feed copper and cobalt ore grade fluctuations, along with instability in the national power grid, often result in extended periods in which copper throughput is below target production. In order to recover target copper mass transfer from these lower throughput periods, the plant compensates by increasing volumetric flow throughput to the SX circuits. High gangue acid (GAC) content in some feed ore results in periodic high levels of talc fines in the leach discharge slurries. This makes liquid–solid separation optimization in the post-leach thickeners and CCD thickeners more challenging. The combination of these operational challenges results in high average levels of total suspended solids (TSS) and high residual flocculant levels in the SX PLS. This translates into high volumes of bottom solids and interface crud having to be managed in the settlers of the five SX circuits, which results in:

- reduced SX volumetric flow throughput and copper mass transfer performance;
- higher impurity entrainments in SX product streams.

Life-of-Mine (LOM) Feed Grade Adjustment

At the end of 2013, the average copper feed grade for the Mutanda operation was gradually adjusted down from 6% to 3.8% contained copper. The reduction in the feed grade copper means that a higher mass throughput of ore is required to maintain target copper production. The reduction in feed grade coincided with commissioning of a 600 dry t/h capacity semi-autogenous (SAG) mill to increase the ore throughput. The drop in LOM feed grade and the inclusion of a different grinding mill mechanism resulted in increases in design flow throughput and altered the particle size distribution of the leach solids from January 2014. Figure 8 shows the TSS levels for PLS feed solutions to the five SX circuits for the period 01 January 2014 to 15 August 2014.

From the end of January 2014, once the 600 t/h SAG mill was commissioned and ramped up to design capacity throughput, there was a steady increase in PLS TSS levels for all PLS streams. The higher TSS levels reporting to the SX circuits resulted in compromised SX performances and plant availability due to increased entrainment levels and more frequent bypassing of SX settlers for solids clean-out.

Crud Forx™ Implementation

On 22 March 2014, the first Crud Forx unit was implemented for SX settlers on-line bottom solids clean-out. The units were systematically rolled out to all five SX circuits.

Impact of Crud Forx™ On-line SX Bottom Solids Management

Figure 9 shows the average hourly copper mass transfer for each of the five SX circuits at Mutanda from mid-December 2013 to mid-August 2014.

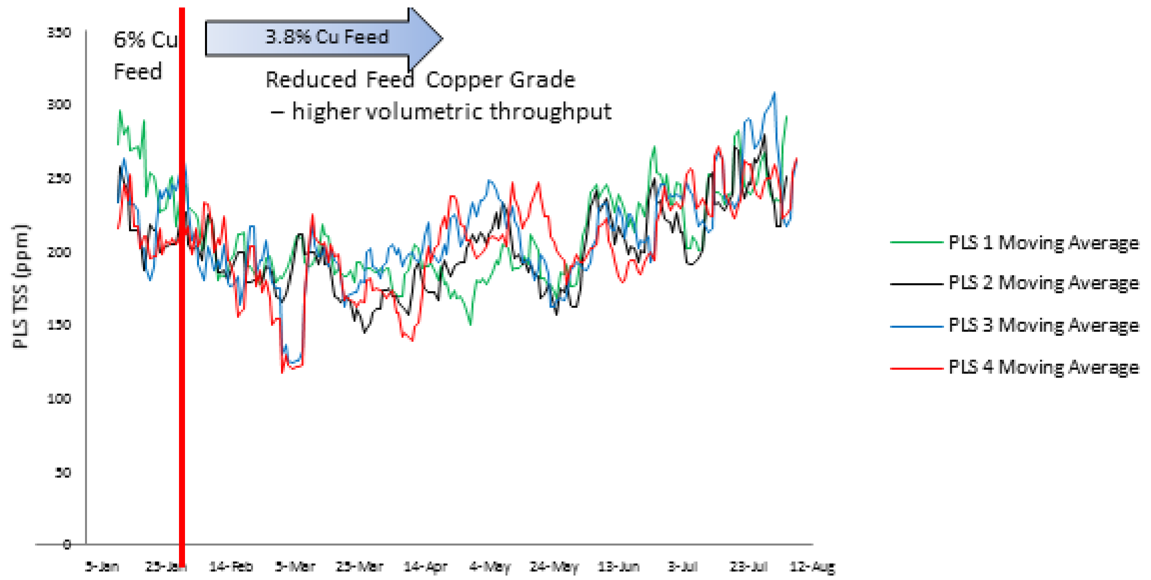


Figure 8. Mutanda Mining SARL PLS TSS levels (1 January 2014 to 15 August 2014).
(Source: Mutanda Mining Operational Data, 01 January 2014 to 07 August 2014. SX Circuits PLS TSS.)

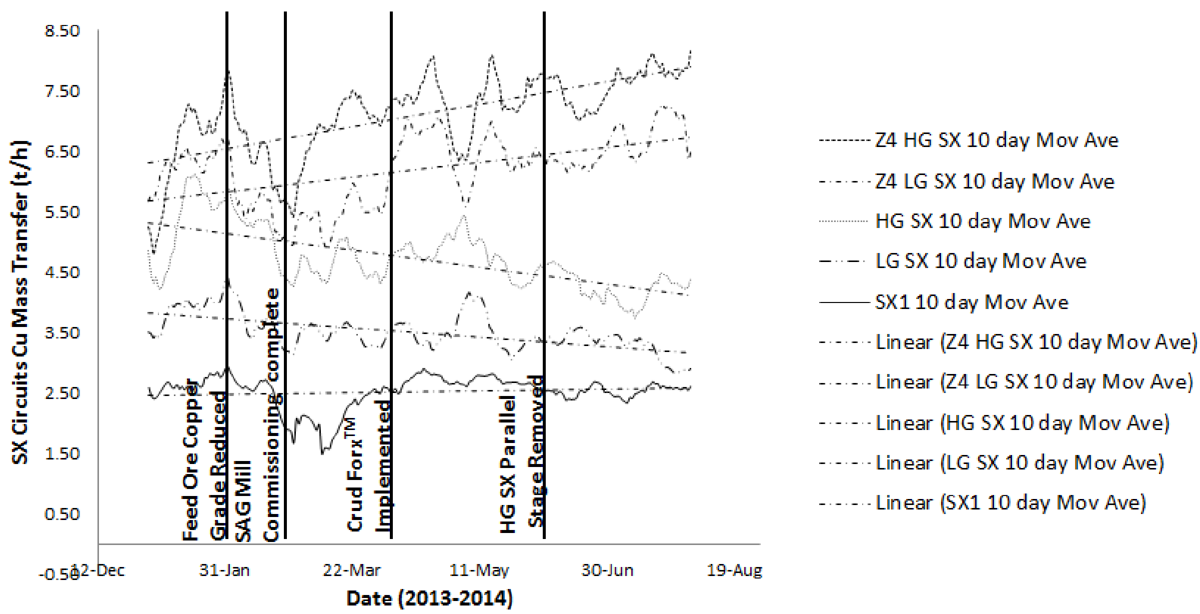


Figure 9. Mutanda SX circuits copper mass transfer (Dec 2013 to August 2014).
(Source: Mutanda Mining Operational Data, 01 January 2014 to 11 August 2014 – SX Circuits Copper Mass Transfer & SX Utilization factors.)

The impact of the Crud Forx ™ implementation is most noticeable on the two largest Mutanda SX circuits (Z4 HG SX and Z4 LG SX), which feed the three largest EW tankhouse complexes.

The decrease in the HG SX circuit copper mass transfer was due to the forced removal of a parallel PLS stage duty from this particular SX circuit in May 2014. The cause of the forced modification to the circuit operating configuration was as a result of an in-line bypass organic valve failure which could not be repaired without significant plant down-time. This prevented the HG SX circuit from being operated at an optimum series/parallel/parallel extraction mixer–settler configuration (three PLS streams) and the circuit being reverted back to a series/ parallel (two PLS streams) extraction mixer–

settler configuration only. For the period between Crud Forx implementation and before the forced change in circuit configuration (11 May) however, copper mass transfer for the HG SX circuit increased.

The relatively constant mass transfer performance of the LG SX circuit was mainly due to constraints on the spent electrolyte flow to this circuit. There was also only a slight improvement in the SX1 copper mass transfer, as this circuit historically has excess capacity to transfer copper, however is limited by the associated downstream tankhouse rectifier capacity.

Table II shows the conservative improvement in copper mass transfer for the individual and collective Mutanda SX circuits.

Table II. SX circuit improvements in copper mass transfer.

SX circuit	Average copper mass transfer improvement (based on average hourly mass transfer) (%)
SX 1	7.8
HG SX	–11*
LG SX	–8.8*
Z4 HG SX	12.1
Z4 LG SX	16.2
Combined SX circuits	4.7

CONCLUSIONS

SX Operational Risk, Health & Safety and Housekeeping Improvement

The implementation of the Crud Forx application at Mutanda Mining reduced the frequency of having to drain affected SX settlers for off-line solids clean-out. The off-line draining of SX settlers often results in large volumes of drained organic being transferred to the SX bunded area. The inherent increase in fire risk and occupational health risk associated with off-line SX settler solids clean-out has been mitigated by implementing the on-line bottom solids management with the Crud Forx. Overall SX housekeeping standard, as a result of the reduced frequency of off-line settler solids clean-out, improved noticeably.

Crud Treatment Unit Operations (Tricanter Centrifuge) Availability and Utilization

The Crud Forx application results in a higher solids density slurry being removed. This means that there is a higher solids mass removal per volume of crud slurry reporting to the downstream crud treatment circuits. At Mutanda, this resulted in a debottlenecking of the crud Tricanter centrifuge operations.

SX Copper Mass Transfer Improvement

The implementation of the Crud Forx application has had a significant impact in improved SX copper mass transfer at Mutanda and contributed positively to assist the operation in maintaining copper production targets for most of 2014. This positive trend has continued in 2015, with the operation increasing the number of Crud Forx units being applied to the SX circuits.

REFERENCE

Virnig, M.J., Olafson, S.M., Kordosky, G.A. and Wolfe, G.A. (1999). Crud formation: field studies & fundamental studies, Henkel Corporation, Arizona.