PROCESS DEVELOPMENTS AT TAILINGS LEACH PLANT

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ABSTRACT

KCM made a major modification to the Nchanga Tailings Leach Plant (TLP) changing the circuit from feeding post leach thickeners in parallel with leach discharge for solid –liquid separation to a Counter Current Decantation (CCD) configuration utilising most of the existing equipment. The new circuit is aimed at improving copper recovery from approximately 70% to 79% through enhanced wash efficiency.

The re-introduction of CCD circuit at elevated throughput of 46 000-tpd design was made possible due to the EIMCO E-Duc technology design which is an auto-dilution system that enhances solids settling rate.

Commissioning (manual operation) which accommodated on-going operational requirements was phased and completed in January 2004. The circuit stabilised in subsequent months and in March alone an all time record copper recovery of 81.8% was achieved which contributed an extra 779 tonnes copper above the plant's projected production plans. 100% of the project cost was paid back by end of April 2004.

This paper discusses the work involved and the challenges faced during the re-commission

1.0 TAILINGS LEACH PLANT, AN OVERVIEW

From inception, Tailings Leach has been developed in three stages. The operation started with leaching of low-grade tailings using strong sulphuric acid followed by solution recovery and cementation of copper. The capacity then was about 1000 tonnes of copper per month**.**

In 1973/74 the second phase, TLP II (See Fig 1), was commissioned with the introduction of a Solvent Extraction plant and an Electrowinning facility. TLP II consisted of various sections including Dewatering, Leach, Washing (Using CCD's), Solvent Extraction, Electrowinning, Lime Slaking, Neutralisation and Disposal. Production was 200 tonnes primary copper per day, and the throughput was 24,000 tonnes per day of dry solids.

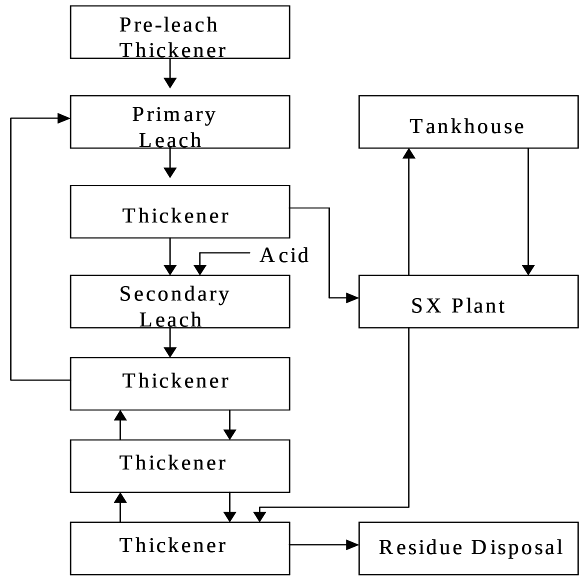

Figure 1: TLP II Circuit

The third phase of the operation (TLP III) was commissioned in 1986. A Horizontal Belt Filter plant was incorporated, and the CCD's were decommissioned during this phase. Throughput was 40,000 tonnes dry solids per day and about 230 tonnes of primary copper per day.

The plant has undergone further expansions since 1986 and has had a residue flotation section added to it to recover some of the sulphide copper which is normally lost in the final residue. The Residue Floatation Plant has since been decommissioned. A flotation plant was also commissioned in the Solvent Extraction section to recover entrained organic from Advance electrolyte to reduce on the losses and consumptions of these reagents. Other developments for the future include efforts directed at the heap leaching of refractory ores.

The latest modification has been the re-commissioning of the Counter Current Decantation circuit in 2003 in the month of October. The nominal throughput was 42,000 tonnes dry solids per day and about 250 tonnes primary copper per day.

	Throughput (Tonnes per day)	Copper Production (Tonnes per day)	Plant Efficiencies (%)		Overall Recovery (%)
			Leach	Wash	
TLP I		30			
TLP II	24,000	200	80.0	88.0	70.0
TLP III	40,000	230	80.0	88.0	70.0
Current	42,000	250	84.0	95.0	79.0

Table 1: Nominal Capacities, Plant Efficiencies and Recoveries

2.0 INTRODUCTION

The Counter-Current Decantation (CCD) system was decommissioned during TLP III as the thickeners could not cope with the raised throughput. Instead, the post leach discharge was fed into two parallel thickeners for single stage thickening. The high copper tenor underflow from these thickeners was then sent to the filters for further recovery of solution copper.

Beginning the year 2000, a lot of capital work was put into the rehabilitation of the filter plant. This was hoped to arrest the poor performance of the filters. However, the performance of filters, even after rehabilitation, failed to meet the expected performance. Losses of copper due to low wash efficiencies continued, and the filter plant was proving to be too costly to run. A more efficient mode of operation was clearly required.

In 2002, plans to re-commission the CCD’s were put in place. The CCD circuit configuration aimed at sending terminal thickener underflow to the post leach filtration circuit with very low copper content possibly for dewatering only. At zero wash ratios, the Horizontal Belt Filters (HBF) filtration capacity was expected to improve utilising approximately 50% of the existing capacity. The CCD wash efficiency was expected to improve to 95% with the overall copper recovery attained being 79%.

The question of thickener throughput again came up, but this time around technology was available. The EIMCO E-Duc technology was identified. Actual work on the plant started in January 2003, phased commissioning was started in October 2003 and was completed in January 2004. After some teething problems, the CCD’s have stabilized and were fully tested in March 2003 when the plant achieved an overall recovery of 81.8% against target of 79.0%.

The E-Duc technology has been extended to the pre-leach thickeners to improve flexibility of the plant. A split circuit, with solvent extraction in series/parallel, is planned for the future.

3.0 FLOWSHEET

Circuit prior to the re-commissioned CCD

The reclaimed dam tailings and current tailings were dewatered in their respective pre-leach thickeners and their underflows combined and sent to the pre-leach HBF before re-pulping with raffinate and transfer to the leach pachucas. The leach discharge was split and fed into two separate post leach thickeners whose overflow was clarified in the other two thickeners producing clear PLS fed to the solvent extraction (SX) plant. The underflow was sent to the post leach HBF to recover soluble copper before disposal of the residue. Fig 2 in a block flow diagram below illustrates the circuit configuration.

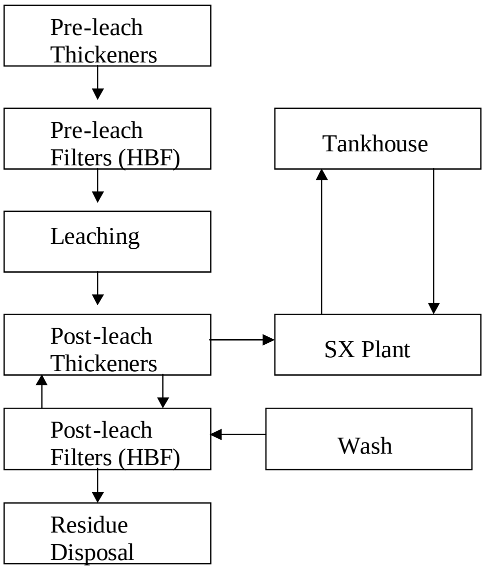

Figure2: TLP Circuit Prior to Re -commissioned CCD

Re-commissioned CCD

At pre-leach thickening the current proposal is to use the reclaim pre-leach thickener (RPLT) after completing installation of the EIMCO E-Duc auto dilution system and keep the current pre-leach thickener (CPLT) on standby.

The leach slurry is received in one thickener (CCD 2) and the underflow washed with raffinate and post leach filtrate in a three stage CCD circuit (CCD 3 to 5). The overflow from CCD 2 is pumped to CCD1, which acts as a clarifier. The recommisioned CCD circuit is illustrated in figure 3 below.

The underflow from CCD 5 is pumped to the acid filters where it is filtered before disposal of residue. The combined filtrate returns to CCD 5. The required amount of overflow from CCD 3 is pumped to the pre-leach filtration circuit where it is used to repulp the pre-leach filtercake. The balance of the solution is pumped to the leach pachucas where it is used for dilution.

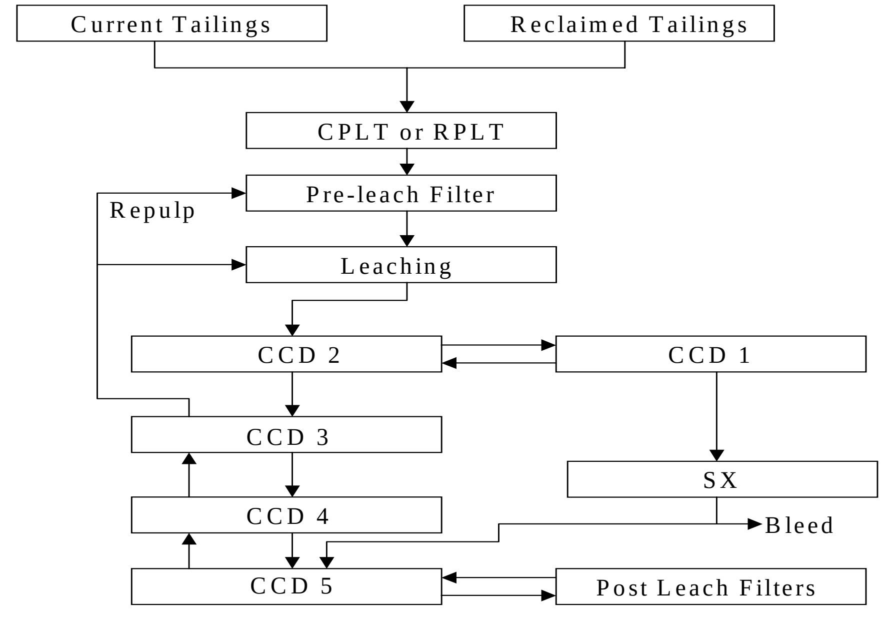

Figure 3: Re-commissioned CCD Circuit

4.0 EQUIPMENT

The EIMCO E-Duc technology

The CCD was able to be introduced again to treat high nominal throughput of 42, 000 tonnes per day (design 46, 000 tonnes per day) due to the patented EIMCO E-Duc technology installed on CCD 2 to 5 while CCD 1 was to be used as a clarifier therefore not modified.

The E-Duc system suitable for high throughput treatment is an auto dilution design comprising an inclined feed pipe to achieve required slurry driving force, energy dissipation section, eductor nozzle and the slurry-mixing channel as shown in fig 4. The discharging slurry velocity entering the slurry-mixing channel through the nozzle that is located just below the liquid level is used to draw the supernatant for dilution and flocculant is distributed in this zone for maximum mixing.

The effective datum for the hydraulic and process requirements for an E-Duc installation at thickener centre is the thickener weir elevation and corresponding water level. The TLP installation partly shown in fig 5 was calculated as 51mm above the thickener overflow weir at the highest flow condition.

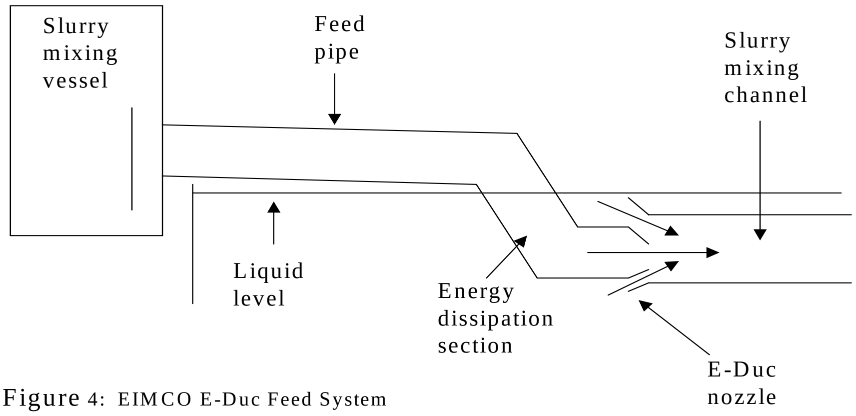

Figure 4: EIMCO E-Duc Feed System

Fig 5. CCD 4 E-Duc installation works in progress**.**

The post-leach thickener feed on the plant contained 30 % solids. Test work at Anglo American Research Laboratories RSA (AARL-RSA) was carried out at feed densities of 30, 22, 17, 11 and 7 % solids to determine the optimum amount of feed dilution required. The results in table 1 showed a similar trend as that of the pre-leach material. The optimum feed density was 10 - 15 % solids, requiring a thickener area of 2.10 m2/t/h. The E-Duc nozzles were then designed to achieve the appropriate dilution.

Feed Solids	TU	Co	Ho	Settling Rate	Area
(%)	(hr)	(t/m3)	(m)	(m/hr)	(m2/t/hr)
30	0.233	0.37	0.21	0.51	2.935
22	0.133	0.26	0.21	1.1	2.429
17	0.087	0.19	0.21	1.92	2.118
11	0.053	0.12	0.21	3.49	2.099
7	0.033	0.07	0.21	5.85	2.117

Table 2: Post Leach - Effect of Feed Dilution
(10gpt flocculant and 55% solids underflow)

Mixing vessels and baffle design

The mixing vessels (MV) situated next to the thickener sidewall receive inter-stage slurry and wash solution before discharging into the E-Duc feed pipe through the baffle. The MV designed to hold sufficient head, allows for escape of any entrained air and mixing of the incoming streams to ensure high soluble recovery. The baffles were modified to extend down to within 450mm from the bottom to maintain a high enough velocity and prevent sanding.

5.0 CCD CIRCUIT SIMULATION

SysCAD simulation software from Kenwalt conducted by Simutron RSA was used to ensure integrity of the CCD hydraulics given the limited static head available between the thickener launder and the downstream mixing vessel. This was necessary to ensure that sufficient driving head was available for the E-Ducs to effect desired dilution and to ensure that the thickener launder would not overflow. The dynamic simulation also allowed checks to be made on pumping calculations made by KCM and underflow pumps supplier (Weir-Envirotec and Warman). The KCM and supplier recommendations compared well with the simulation results and the gravity overflow simulation recommendations were adopted for implementation. The simulation results on underflow pumps and overflow gravity lines are shown in tables 3 and 4, respectively.

Equipment	Pump head (m)	Pump speed (rpm)	Efficiency (%)	Power absorbed (Kw)
CCD 5	14.68	448	72	78
CCD 4 normal	20.24	507	75	117
CCD 4 bypass	26.33	565	75.5	168
CCD 3 normal	13.56	438	70	72
CCD 3 bypass	15.42	456	75.5	83

Table 3: Summary of Underflows

6.0 THICKENER UNDERFLOW PUMPING

A third electronic v-belt driven variable speed drive (VSD) pump 14/12 fitted with 200kw motor mounted above the pump were added to the existing two fluid drive VSD pumps fitted with 375kw motors at the thickener underflow pump chamber CCD 2 to CCD 5.

Electronic VSD pumps are attractive economically for low electrical rating applications limited to about 370kw. Some of the benefits are high-energy efficiency and no impact on pump layout. However, the electronic VSD's require additional space in the of the motor control centre (MCC) in order to accommodate drives and ventilation.

One challenge was to mix the operation of the electronic VSD pumps with the fluid drive pumps. This was largely attributable to the fact that the pumps are operated in parallel and need to be operated at roughly the same speed. This did not prove to be a problem as a reasonably close match in speed could be achieved not withstanding the fact that the pump curves are quite flat and relatively forgiving.

Initially the 160kw constant 200kw peak electronicVSD's were undersized providing inadequate break out torque. This was overcome by decreasing the pulley ratios for lower power requirement at the prime mover on start up. The motor was run slightly faster using the VSD to compensate for the reduced pulley ratio. The plan now is to go for 200kw constant 250Kw peak VSD's to avoid this problem.

Currently two pumps running and one on standby are able to handle 1918 tph solids at 50% solids by weight. The underflow pipes at 500nb were not upgraded as it was assumed that they would handle the high line velocities of the order of 3.7m/sec. Upgrading these lines is under consideration.

7.0 THICKENER OVERFLOW – GRAVITY AND PUMPED

Gravity overflow lines leading into MV's between the terminal wash thickener (CCD 5) located on the higher ground and the first wash thickener (CCD 3) on the lower side were redesigned to 1200nb and those leading to pump station were upgraded to 800nb to sufficiently handle 3645 m3/h solutions.

A pump station to handle leach solution (CCD 3 or 4) and PLS for clarification (CCD 2 or 3) was constructed. The leach solution at a flow rate of 3645 m3/h was to be pumped using fixed drive 250KW 14/12 (D-frame) v-belt driven pumps and the PLS at a flow rate of 2806 m3/h was to be pumped using fixed drive 75KW 14/12 (D-frame) v-belt driven pumps. The 75KW motors will be upgraded to 132kw motors to increase flow to 3000 m3/h and contain flow surges originating from CCD 3 bypass operation. A slightly lower flow of leach solution is tolerated to Pachucas due density issues. Both delivery lines were sized to 600nb.

Equipment	Normal Operation		Bypass Operation	
	Line Dia	Launder Level	Line Dia	Launder Level
	(mm)	(%)	(mm)	(%)
CCD 5	1000	2.06	1000	-
CCD 4	1000	26.00	600	1.8
CCD 3	700	7.06	700	-
CCD 2	700	2.00	-	-

Note that standard sizes of 1200mm and 800mm were used.

Table 4: Summary of Overflows

8.0 CONTROL AND INSTRUMENTATION - MODE OF OPERATION

The CCD control philosophy with regard to the thickener solids control was by varying the speed of the underflow pumps. The CCD 2 and 3 overflow from fixed drive pumps was to be controlled by discharge line auto valves actuated from level detection signal in the respective thickener launder.

The overall flow system behaviour was to be controlled by raffinate auto valves – bleed and recirculated as illustrated in figure 6.

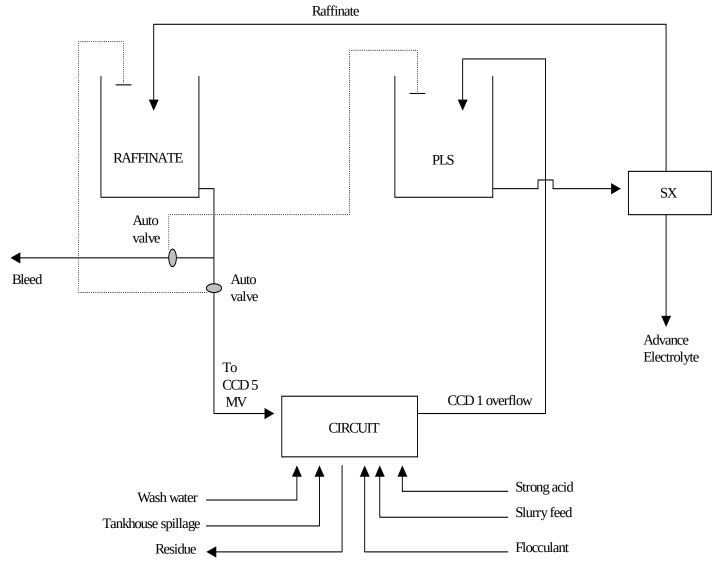

Fig 6: CCD Overall Flow System Control

The valve on the bleed stream was to be actuated from the PLS tank level detection signal whereas the valve on the recirculated flow was to be actuated from the raffinate tank level detection signal. The opposite was also possible but a steady condition was expected with this configuration due to an almost fixed inflow of raffinate from SX plant keeping the level almost constant and therefore keeping the flow to CCD 5 fairly steady. Any changes in the system would be taken care of through the bleed stream.
Flocculant addition auto system was to be based on the feed forward control vis-à-vis mass flow from previous thickener underflow controls flocculant addition to the next to overcome the relatively long time lag.

9.0 E-DUC RETROFITTING AND COMMISSIONING

Manual operation commissioning (installation and testing of instruments were not completed) accommodated on-going operational requirements and was phased which completed in January 2004.

The first two thickeners that were retrofitted with E-Ducs were CCD 5 and CCD 4 while CCD 1 and 3 received leach discharge with CCD 2 as a clarifier. The next stage of retrofitting was planned to use CCD 4 as a receiving thickener after completion of E-Duc installation. However, due to Nkana Smelter shutdown which resulted in reduction of acid supply (up to about September 20, 2003) it was possible to use CCD 1 as a receiving thickener. This allowed CCD 3 to be converted and gave additional time to refurbish CCD 4.

The initial phase of commissioning involved a mini-CCD circuit that comprised one receiving thickener (CCD 3), two wash thickeners (CCD 5 and 4) and a clarifier (CCD 1) whilst CCD 2 was being retrofitted.

The second phase of commissioning to complete the circuit with three wash stages involved diversion of the leach discharge to CCD 2 and maintained CCD 1 as a clarifier.

10.0 COMMISSIONING CONSTRAINTS

Tabulated below, in Table 5, are some of the CCD commissioning challenges encountered.

PROBLEM	SOLUTION
1. Electronic VSD start up failure with solids in pump casing.	1a. Decreased pulley ratios. 1b. Installed flushing water.
2. Failure of old u/flow pipes.	2. Carried out renewal programme.
3. Failure of fluid drive pumps.	3. Site based repair.
4. Insufficient circuit flexibility.	4. Implemented further flexibility to acid HBF – additional valves ordered to replace spades.
5. New pumps tripping.	5a. Changed bus-coupler settings. 5b. Installed additional transformer as per design
6. Thickeners tripping on load.	6. Enhanced operator control. Tto incorporate auto rake lift with torque increase & bed level detection.

Table 4: Commissioning constraints

11.0 THE CCD PAY BACK

Approximately US$ 4.5 million was spent from an initial estimate of US$ 3.6 million. The excess expenditure was mainly due to the existing plant failures, which had to be maintained within the project budget.

The CCD production performance and revenue is shown in table 6 below. In March alone an all time record copper recovery of 81.8% was achieved which was 2.8% above the design target contributing an extra 779 tonnes copper above the plant's projected production plans and 100% of the project cost was paid back end of April.

Month 2004	Base Recovery (%)	CCD Recovery (%)	Actual Recovery (%)	Additional Copper (tonnes	Copper Price (US C/lb	Benefit (US$)
February	73	79	76.7	290	1.35	862,994
March	73	79	81.1	779	1.35	2,316,563
April	73	79	79.3	464	1.35	1,379,821
Total				**1532**		**4,559,378**

Table 6: CCD Payback

12.0 CONCLUSION

The EIMCO E-Duc technology is an auto-dilution system making it possible for KCM to modify the existing Tailings Leach Plant and re-introduce the counter current decantation circuit, this time treating high tonnage of the order of 42,000 tonnes per day. Increased copper recovery through efficient washing of solids before filtration and residue disposal is a significant process requirement. The circuit has already shown potential to meet its design performance with manual control. The re-introduced CCD circuit configuration provides an opportunity to further increase revenue by implementing a split circuit with solvent extraction in series/parallel configuration.

13.0 FUTURE OUTLOOK

In combination with the CCD circuit, the future plan for TLP is to implement a split circuit with solvent extraction in series/parallel configuration.

Low-grade circuit pregnant leach solution will originate from CCD 3 to produce low tenor raffinate directed to the terminal CCD thickener for washing and if need be, bleed stream will come from this circuit. The benefits will be a further reduction in copper losses through residue disposal and neutralisation costs.

High-grade circuit pregnant leach solution will originate from CCD 1 to generate high tenor raffinate returning to leach. This will benefit leaching and lower acid consumption.

14.0 REFERENCES

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