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Phasing out Reverberatory Furnace Operations at KCM Nkana

C.J. Cutler, M. Natarajan §, E. Mponda §, and J.J. Eksteen
University of Stellenbosch, Stellenbosch, South Africa
§ KCM Nkana, Kitwe, Zambia

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Abstract – The Nkana smelter was initially commissioned in 1931, with two reverberatory furnaces, two Peirce-Smith converters, and blister copper casting facilities. Reverberatory furnaces were the mainstay of production up until 1994, when an El Teniente Converter (CT) was installed to upgrade reverberatory furnace matte to white metal, prior to converting in conventional Peirce-Smith (PS) converters.

In 2000, a decision was taken to increase the proportion of concentrate smelted in the CT by introduction of bone-dry concentrate injection through the tuyeres. A flash dryer with a nominal capacity of 1 200 metric tons per day of dry product, and associated tuyere injection system was commissioned in March 2004.

Based on the projected concentrate arisings from the KCM mines into the future, as seen in 2004, it was decided to develop the CT to be the primary smelting vessel at Nkana, to handle a minimum of 1 250 tons per day of concentrate, and to operate only one reverberatory furnace in slag-cleaning mode pending a full evaluation of alternative slag-cleaning technologies. The anticipated cathode production from Nkana was to be in the range 140 to 150 000 tons per annum.

This paper details the outcomes from trials that were carried out in August and September 2004, using two reverberatory furnaces for slag cleaning. The results of these trials, plus further work in October and November, provided confidence to move to one reverberatory furnace for slag cleaning in December 2004.

With the advent of Vedanta as the majority shareholder in KCM at the end of 2004, the approach has been to maximize the available smelting capacity. Currently, two reverberatory furnaces and the CT are on-line, with the higher silica concentrates going to the reverberatory furnaces with an appropriate amount of pyrite, and the cleaner concentrates going to the CT. Expansion of the smelter is currently under investigation.

INTRODUCTION

The Nkana smelter was commissioned in 1931, with two reverberatory furnaces (reverbs), two Peirce-Smith (PS) converters, and blister casting facilities. In the first year of operation, blister production was 6 000 metric tons. At the peak of production in 1971, when 330 000 tons of copper was produced, there were five reverbs and five PS converters in operation, with a sixth PS undergoing maintenance. Production of anodes started in 1960, and, by 1971, there were four units in operation. An oxygen plant of nominal capacity 450 t/d was commissioned in 1970, to allow enrichment of the process air to the reverbs. By the early 1990s, production had fallen to a level of about 200 000 t/a, and in

1993 fell again to around 130 000 tons. Production has been between 100 000 and 125 000 tons per annum since that time.

INTENSIFICATION OF THE SMELTING PROCESS

By the mid 1980s, ZCCM (Zambia Consolidated Copper Mines) management realised that Nkana faced serious operating cost and reliability problems into the future, by continuing to run end-wall-fired reverb furnaces as the primary smelting units. The other driver for change was the need for additional acid for leaching of the Nchanga refractory ores to increase production of electrowon copper.

The 1986 study team's recommendations were to retrofit two conventional reverbs with an oxy-fuel roof-burner system, and install an El Teniente Converter to convert matte plus additional concentrates to white metal. Some of the PS converters would be retained for the conversion of white metal to blister copper.

The first oxy-fuel retrofit was commissioned in 1990. The waste heat boilers used on the conventional reverb were replaced by an evaporative cooling chamber followed by cyclones. It was anticipated that the retrofitted furnace would smelt 800 tons of concentrate per day, compared to 450 t/d with an end-fired furnace using 14 oxy-fuel burners and around 200 t/d oxygen. In the event, the design of the gas-handling system was sufficient only to handle a maximum of nine burners - around 500 t/d concentrate.

The CT was commissioned in August 1994. The main design parameters are given in Table I. The design followed the Codelco practice at the time where seed matte was taken from the reverb furnaces to make up the energy balance and provide a fayalitic slag chemistry with a Fe/SiO_2 ratio of around 1.4/1. In the case of Nkana, this factor is extremely important because Nchanga and Konkola concentrates are deficient in sulphur and iron. The concentrate chemical and mineralogical analyses are listed in Tables II and III. The Nchanga concentrates are predominantly chalcocite, the Konkola concentrates predominantly bornite and chalcocite, and Nkana concentrates predominantly chalcopyrite.

The other difficulty with KCM concentrates is the level of SiO_2 in concentrates; up to 30% in the case of Nchanga medium-grade concentrates. In addition, not all of the silica in concentrate is available for fluxing with iron. Although an overall mass balance for the smelter indicates that no additional silica (beyond that contained in the concentrates) is required to satisfy the slag chemistries for the reverbs and CT, in practice additional silica is required.

Table I: Key CT Operating Parameters

Parameter	Units	Design with Green Charge	Performance Test 14/09/94	Best Performance with Green Charge
Concentrate Treatment	t/d	500	595	672
Concentrate Blend Ratio				
Nchanga/Nkana/Pyrite	%	100/0	50/50	55/36/9
Matte Supply from				
Reverbs	ladles	53	37	19
Matte Grade	%	53	52	57
White Metal Grade	%	75	74	77
Reverts	t/d	0	0	46
Oxygen Enrichment	%	32	27	29

Table II: KCM Concentrate Compositions

Assay %	Konkola	Nchanga HG	Nchanga MG	Nkana
Cu	41.9	39.7	33.7	27
Fe	10.4	10.5	6.3	22.8
S	15.9	11.9	10.8	24
SiO_2	17.9	21.1	30.4	12.8
Al_2O_3	4.8	4.8	6.9	1.6
CaO	1.2	0.7	1	1.9
MgO	1.2	1.6	2.4	4.4
Fe_2O_3	4.5	10.5	4	4.5

Table III: KCM Concentrate Mineralogy

Mineralogical Composition %	Konkola	Nchanga HG	Nchanga MG	Nkana
Chalcopyrite	15.4	3	5	57.5
Bornite	22.2	5.2	3.3	10.4
Chalcocite	23.6	38.1	31.6	0.5
Pyrite	0.2	3.5	3.5	2.1
Pyrrhotite				
Carrolite	1.1	1.8	0.1	0.5
Native copper	1.1	0.1	0.5	0.1
Malachite	2.4	6.3	4	
Pseudomalachite	0.2	0.1	0.2	
Chrysocolla	0.1	0.1	0.1	
Azurite			0.1	
Cuprite	0.5	1.3	1.8	
Microcline	1	9.5	13.5	3.5
Talc	1	3.5	5.1	9.6
Silica	10.7	7.1	10.3	2.9

The effect of the concentrate blend on the main operating parameters is demonstrated in Table I. For the performance test, where the Nchanga/Nkana ratio was 50/50, the matte supply from the reverbs was much less than design, and could have been further reduced by increasing the oxygen enrichment to the design level.

Looking at the numbers for best performance with green charge in Table I, the reverb matte requirement is 35% of design, with further room to move on the oxygen enrichment levels.

ASSESSMENT OF OPERATIONS IN JANUARY 2003

A new direction

Anglo American exited their relationship with KCM in December 2002. They took a management contract rather than an equity position in the Nkana smelter and refinery at vesting in 2000. They had an option to take equity, pending the outcome of their studies into the future of operations after a planned major expansion of the Konkola mine.

Their principal interest proved to be around hydrometallurgical processing of the additional concentrates from Konkola, and not in the development of the Nkana smelter and refinery.

The incoming CEO had the view that the future of KCM was about producing sufficient acid from smelting operations to allow expansion of the leach/SX/electrowinning operations, and so offset the relatively high costs of smelting against the lower costs of electrowon copper.

The direction set for the smelter was to optimize the available equipment, and set the foundations for a competitive smelter and refinery with a production of around 150 000 t/a cathode. This capacity was based on a twenty-year forecast of concentrates from the KCM mines, assuming a modest expansion of the Konkola mine and a limited quantity of purchased concentrates.

Operating philosophy

The operating philosophy at Nkana was to have all of the available vessels either in operation, or hot to help mitigate the effect of any breakdowns.

The difficulty with this philosophy of operation, apart from the unit costs, is effectively spreading the maintenance effort. The net result was poorly maintained equipment, performing well below what could be considered acceptable performance indices. It is easy to see how this came about, given the installed equipment available, and the lack of focus on costs.

An illustration is concentrate throughput. Two conventional coal-fired reverbs with oxygen enrichment have a design capacity of 450 t/d concentrate each.[1] The CT has a design capacity of 500 tons per day concentrate, in green charge mode (with reference to Table I), but the total for the three units at the beginning of 2003 was 8 – 900 tons per day.

Role of the CT

A practice had grown up over the years for all of the reverb matte to go to the CT. This was probably because the design basis for the CT involved the use of seed matte from the reverbs, but, at Nkana, the CT was rolled out if there was no reverb matte available so that copper production was effectively at a standstill. The other side of this practice was that when the CT had no room for reverb matte, the firing rate on the reverbs was cut so that concentrate input to the total smelter was reduced.

The writer's operating experience prior to Nkana was with a similarly sized vessel. The Noranda Reactor is a 'sister' technology to the CT but with a different operating philosophy. The mode of operation is to use much higher levels of oxygen enrichment, no seed matte, and effectively drive the concentrate throughput by the total oxygen input from process air and oxygen. In the case of Nkana, where iron and sulphur levels are lower than for traditional chalcopyrite concentrates, it is not possible to provide the shortfall in energy by oxygen alone, and use of some seed matte is the simplest solution.

The other significant difference between the Chilean (CT) and the Canadian (Noranda Reactor) approach is the white metal grade. The practice at Nkana is to take an end point in the CT of 74 – 77% Cu, and so do away with a slag blow in the PS converters. The downside is that the PS converters tend to build up a layer of high-magnetite slag below the tuyere line, which, if not washed out on a regular basis, limits vessel capacity. The Noranda practice is to take an end point of around 72% Cu, which necessitates a slag blow in the PS converters, usually with oxygen enrichment of the blast air. The downside is skimming the slag from the slag blow, but the upside is cleaner converter barrels and higher reverts and cold dope consumption over the total blow.

Smelter Reverts Handling

At Nkana, the practice was to take all reverts back to the revert-crushing plant and treat them through the reverbs as part of the charge mix. With the CT online, the generation of high-grade reverts appeared to go up; in actual fact they did because of the white metal shells make, but the effect was exaggerated due to reduced consumption of high-grade reverts in PS white metal blows.

Anode Scrap Melting

The Nkana smelter traditionally handled electrowon copper scrap from the Nchanga operations, as well as the by-product copper from the cobalt operations at Chambishi and Nkana, and the Nkana tank-house anode scrap. With the change in PS operations after the CT was commissioned, a surplus of scrap built up, and the duty for #5 converter was changed to scrap melting using heavy fuel oil and oxygen. At a later date, another (spare) converter barrel was converted for scrap melting use using heavy fuel oil and oxygen.

The usual practice was to run one vessel while the other was on maintenance, but both were used together on occasions.

DECOUPLING THE CT FROM REVERBERATORY FURNACE AND PEIRCE-SMITH CONVERTER OPERATIONS

The first step was to carry out mass and energy balances for the CT, based on expected concentrate grades, with a variety of feed mixes to establish the minimum matte requirements for the CT. Metsim was used for this exercise, and the modelling work is reported elsewhere.[2] Cam Harris from HG Engineering assisted with the validation of this work, and it was concluded that, even at concentrate throughputs of greater than 1 000 t/d, there would be a low-grade matte requirement of around ten ladles per day.

The same calculations indicated that oxygen enrichment would need to be raised to 34 – 36%, and that 20 – 40 t/d of coal would be needed - as auxiliary fuel, and to assist in the control of magnetite in the slag to between 18 and 23%.

The other aspect examined was the use of pyrite as a way of closing the iron and sulphur balances in the CT, in addition to, or in place of, reverb matte, and as a tool for matte grade control in the reverb, to maintain the best copper in discard slag. Some trials were run in the CT with up to 30% pyrite on charge, but the net result overall in the smelter was to displace copper units. The optimum result was to use pyrite in the reverb for matte grade control, in spite of the fact that some sulphur was lost to acid as a result, and this was the practice adopted.

The most important task was to increase the specific smelting capacity of the reverb furnaces to around their design capacity of 450 t/d concentrate, or to take one furnace off line in order to reduce unit costs. The poor specific smelting performance was primarily due to the practice of cutting fires either because the CT was not in a position to take the matte or because the furnaces were at high levels due to a breakdown or hold-up in the slag handling system from the reverbs. In the event, the best achieved on a consistent basis was an average of 350 t/d per reverb.

The introduction of mixed blows (reverb matte plus white metal) and straight reverb matte blows in the PS converters was the most important 'culture change' in the de-bottlenecking process. The aim of this change in operation, apart from breaking the dependence of the CT on the reverbs, was to keep a converter in stack at all times, and so reduce the effects of poor gas on the acid plant continuity. Also, because there was always somewhere to take matte, the firing on the reverbs became more stable; reverts/cycle increased, and the problem of build–up in the converter barrels considerably reduced.

REDUCTION IN NUMBER OF VESSELS IN OPERATION

Perhaps the biggest 'culture change' of all was in the reduction of the number of operating units. The first step was to shut down the dedicated scrap melting units, and melt all of the clean scrap in the anode furnaces, leaving the dirty scrap from the tailings leach plant for the converters. The second step was to reduce the number of PS converters from three to two on-line, and the third step was to reduce the number of anode furnaces from four to three on-line. Apart from reducing the unit costs, this change made planned maintenance on vessels easier to implement.

Two other operational changes helped the overall 'culture change'. Consumption of high-grade reverts had been an issue at Nkana since the commissioning of the CT. The practice of taking white metal shell reverts out of the aisle, and handling them through the reverts-crushing system, was discontinued and they are now returned direct to the CT by ladle. Anode slag and high-grade reverts (copper chunks) are now also returned direct to the CT, with the bulk being added when the white metal grade is on the lower side of the target range of 74 – 77% copper.

FLASH DRYING AND TUYERE INJECTION OF BONE DRY CONCENTRATES TO THE CT

In line with the practice being adopted at the time in Chile by Codelco, a decision was taken in 2000 to install a flash drier and concentrate injection system of nominal capacity 1 200 t/d. The project was put on hold in 2002, but was finally commissioned in March 2004. The Nkana flowsheet following installation of the flash drier is given in Figure 1 below.

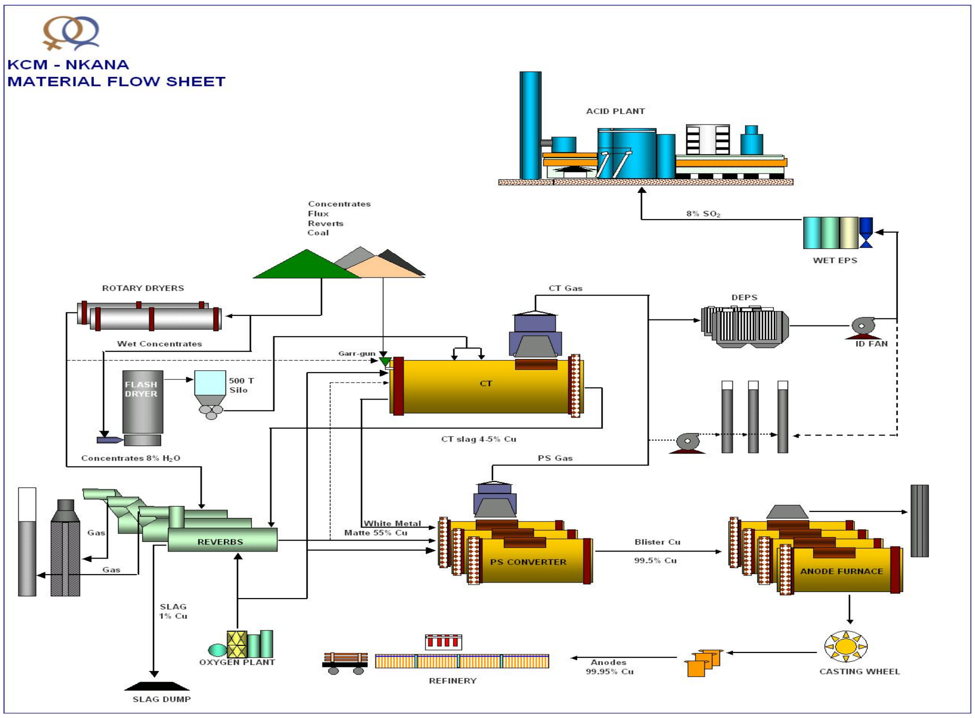

Figure 1: Nkana flowsheet (2004)

There was an abortive attempt to commission the system in September 2003, when the bag-house was seriously damaged by fire during a performance test by Drytech (the supplier of the equipment). The most likely cause of the fire was carryover of coal fines from the coal-fired hot-gas generator.[3]

The early results, in terms of concentrate throughput, were encouraging, with a daily rate of 775 tons achieved in May, but there were also some significant early problems in terms of wear on the injection tuyere inner pipes and 'shoes' which change the feed direction, as well as the distribution pipe-work on the vessel itself. To a large degree, those initial problems have been resolved, and the vessel is consistently recording daily figures of around 1 000 tons dry concentrate feed. The tuyere injection system for the converters is shown in Figure 2.

The issue of excessive wear of the tuyere line around the injection tuyeres was significantly reduced by blanking off two conventional tuyeres on either side of the two injection tuyeres, but it still remains an issue because it is likely to be the factor determining the operating time between tuyere-line hot repairs.

TUYERE INJECTION SYSTEM

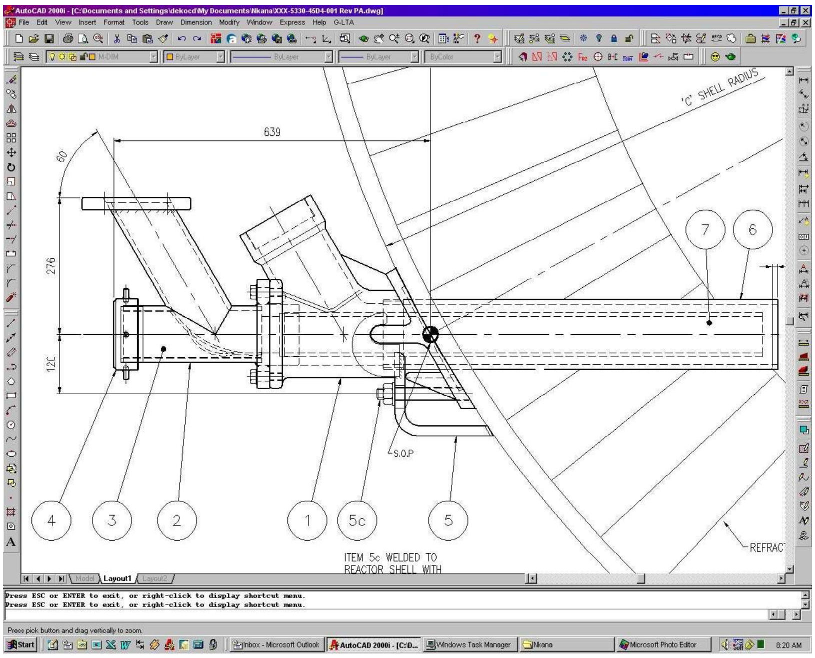

Figure 2: Tuyere injection system for the CT Converter

Another early issue was the control of the bath temperature at high injection rates. This was solved by dedicating one green feed bin to crushed reverts, which could then be added as required; in practice, 50 – 100 t/d of crushed reverts are now added daily - another useful step in reducing the reverts load to the reverbs.

The overall assessment from the first two months of operation was that the CT had the capacity for treating at least 1 250 t/d of concentrate, and that what was now needed was to concentrate on how to handle the higher tonnage of CT and PS slag through the reverbs, and maintain acceptable copper levels in the discard slag.

CT AS PRIMARY SMELTING VESSEL AT NKANA, WITH REVERB SLAG CLEANING

In mid 2004, the outlook for KCM concentrate supply into the future, based on expansion of the Konkola mine, was around 500 000 tons per annum, with an equivalent cathode production in the range 140 – 150 000 t/a.

Studies on the continued use of the CT, or installation of Isasmelt technology, were carried out with the assistance of INDEC and Kvaerner, to determine capital and operating costs for the two options. Both cases assumed installation of an electric furnace for slag cleaning at a later stage, with interim use of the reverbs for slag cleaning.

The least-capital option, and the option with the least technical risk, given the nature of the KCM concentrates, and performance of similar-sized units in Chile, was to continue with the CT using an appropriate amount of low-grade reverb matte to make the required Fe/SiO_2 ratio in CT slag, and/or close the energy balance.

It should be noted that there were considerable reservations from the operating team at Nkana about the practicality of electric furnace slag cleaning, where only a high-grade matte could be simply produced, as this option puts pressure back onto the CT for the closure of the energy balance, and the PS converters for build–up, and reverts and scrap consumption. Pyrite can be added to an electric furnace, to reduce matte grade, but there are significant problems with gas handling and the added complication of feed bins.

In the light of the work done at Cyprus Miami, with an electric furnace, previously used for smelting, as a slag-cleaning unit, and at Sterlite Tuticorin, using a rotary holding furnace as a slag cleaner, it was decided to proceed with trials using a reverb furnace as a slag cleaner.

REVERBERATORY FURNACE SLAG CLEANING TRIALS

The first step was to monitor operations on #3 and #4 reverbs on a twenty-four hour basis, for a period of five days. Particular attention was paid to the following :

- furnace level control and skimming practice
- slag train movements
- copper and magnetite in discard slag
- slag temperatures

- distribution of return slag from the CT and converters between the two reverbs

The detailed results are the subject of an internal report.[4] Slag temperatures were generally around 1275°C in both furnaces. The reverb furnace discard slag data is given in Table 4.

Table IV: Reverb Furnace Discard Slag Data

	09-Aug	10-Aug	11-Aug	12-Aug	13-Aug	Average
#3 Furnace						
%Cu	0.75	0.7	1.48	1.18	1.04	1.03
%SiO_2	33.6	40.0	36.7	31.0	35.3	35.3
%CaO	4.7	3.3	3.8	3.6	1.7	3.4
%Fe	30	28.6	32.1	33.1	33.7	31.5
%Fe_3O_4	6.0	2.5	4.5	2.8	5.0	4.2
#4 Furnace						
%Cu	1.1	1.36	0.78	1.19	0.78	1.04
%SiO_2	32.9	40.9	38.2	34.7	37.3	36.8
%CaO	3.6	1.6	3.1	2.3	2.6	2.6
%Fe	31.5	36.6	36.1	34.6	33.8	34.5
%Fe_3O_4	6.0	7.0	8.0	9.0	10.0	8.0

The monitoring period showed significant operating problems in both furnaces, but particularly #4, which was taking 60% of the return CT, and PS slag. #4 furnace ran slag levels of > 14 inches for 90% of the skims, and matte appeared on 25% of the skims. #3 furnace ran between 12 and 14 inches for 65% of the skims, with matte appearing on 5% of the skims. Copper levels in discard slags were > 1% for both furnaces, and magnetite levels in discard slags were high (> 4%), particularly for #4 furnace where the average was 8%.

This survey showed that the matte sumps were poor on both furnaces, and that there were effectively no settling areas that would allow reduction of magnetite to take place. As a result, it was decided to implement the technique used in the rotary slag-cleaning furnace at Sterlite Tuticorin where cast iron is added to assist with magnetite reduction.

REVERBERATORY FURNACE SLAG CLEANING TRIALS, USING CAST IRON AS A REDUCTANT

The same base parameters as for the initial work were monitored twenty-four hours per day for nine days. In addition, around two tons per day of cast iron was added to each furnace in a prescribed pattern. At the same time, air pipes were used to agitate the area around the matte tap holes.

The detailed results are the subject of an internal report.[5] The data for discard slag composition and slag temperatures is given in Table V.

Table V: Reverb Furnace Discard Slag Data

	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug	01-Sep	02-Sep	Average
# 3 Furnace										
%Cu	0.66	0.58	1.02	1.05	0.63	0.80	0.65	0.80	1.10	0.81
%SiO_2	42	46.8	43.1	34	37.5	40.2	34.2	38.5	33.8	38.9
%CaO	4.2	6.2	5.5	7.5	6.3	6.2	9.2	10.8	12.8	7.6
%Fe	25.6	18.6	31.5	26.2	27.8	27.5	26.3	23.6	26.7	26.0
%Fe_3O_4	3.1	1.3	4.2	4.2	2.9	1.3	4.0	1.1	1.1	2.6
Random Temp ^oC	1260	1277	1266	1321	1340	1352	1257	1315	1301	1299
# 4 Furnace										
%Cu	1.15	1.19	0.48	1.05	1.08	1.43	2.06	1.50	0.73	1.19
%SiO_2	38.6	40.0	35.3	39.2	33.8	31.2	28.3	32.8	44.7	36.0
%CaO	6.6	5.2	2.8	4.7	5.1	4.2	4.4	8.8	6.6	5.4
%Fe	30.8	26.6	35.1	26.7	30.8	36.1	40.7	30.2	29.9	31.9
%Fe_3O_4	4.5	1.5	5.1	5.2	5.0	6.4	5.8	6.0		4.9
Random Temp ^oC	1237	1258	1220	1238	1247	1243				1241

For this monitoring period, the levels in both furnaces were under control, although #4 ran at higher levels than #3. The average level for #3 was 12 inches, and for #4 15 inches. Both furnaces treated about the same tonnage of CT and PS slag per day, and took about the same amount of charge per day. #3 furnace responded well to the treatment with cast iron, as the sumps opened up and matte was not recorded on any of the skims. Copper in slag reduced to an average of 0.8%, and magnetite to an average of 2.6%. #4 furnace did not respond as well, although there was an improvement in the sumps but not to the extent of #3. Magnetite in slag remained high, at an average of 4.9%, and copper in slag was high at an average of 1.2%.

CONCLUSIONS FROM THE SLAG CLEANING TRIALS

Use of cast iron as a reductant, together with agitation around the matte tap holes, helped maintain the settling areas in the reverb, and is an important mechanism for keeping low levels of magnetite in discard slag. With good furnace level control, and magnetite levels in discard slag < 4%, it is possible to maintain < 1% copper in discard slag over the long term.

A purpose-built reverb furnace with a combination of end-wall coal-firing and oil/oxy-fuel roof-firing would have sufficient settling capacity to handle all the CT and PS converter slag for a smelter throughput of 1 500 t/d concentrate. In this case, the split of concentrates would be 1 250 t/d to the CT and 250 t/d to the slag-cleaning reverb.

PREPARATION FOR CT AND ONE REVERB OPERATION

Cast iron additions to both reverbs, and agitation around the tapholes, was continued during October and November, along with close monitoring of hearth condition. Six points were monitored in each furnace. The results for the two furnaces are summarized in Table VI below.

Table VI: Results Summary for October and November

	October	**November**
Dry Concentrate Throughput – t/d		
- # 2 Reverb	312	305
- # 4 Reverb	309	192
- CT	547	443
- Total	1168	940
Reverts – t/d		
- # 2 Reverb	164	170
- # 4 Reverb	170	103
Return CT + PS Slag - ladles/day		
- # 2 Reverb	13	19
- # 4 Reverb	13	10
Cu in Discard Slag - %		
- # 2 Reverb	0.81	0.78
- # 4 Reverb	0.93	1.03
Furnace Levels - inches		
- # 2 Reverb	10	6.5
- # 4 Reverb	15.5	13.5
Hearth Measurements - metres		
- # 2 Reverb	6.43	6.48
- # 4 Reverb	5.97	5.59

In October, the split of concentrate between #2 and #4 reverbs was approximately equal, as was the reverts. CT plus PS slag was equally split between the two furnaces. The average hearth measurements in #4 furnace were 0.46 m less than #2 furnace, and, to some extent, this is reflected in the furnace levels, which were an average of 15.5 inches for #4 furnace, as compared to 10 inches on #2 furnace. Copper in discard slag for both furnaces was < 1% on average.

In November, the concentrate and reverts throughputs for #2 furnace were similar to October, but the throughput to #4 was reduced significantly. The amount of CT and PS return slag returned to the reverbs was not in the ratio of concentrates charged, with more going to #2 than to #4. While furnace levels in #4 furnace were less than in October, the build-up in the hearth increased from October, in spite of routine cast iron additions. #2 furnace levels were well under control in October, and consistently met the target level of 6 – 7 inches. Copper in discard slag for #2 furnace was similar to October, but was > 1 % for #4 furnace.

In summary, #2 furnace performed well as a slag-cleaning furnace during November. Particular attention was paid to the cast iron additions and skimming practice.

CT AND ONE REVERB OPERATION IN DECEMBER

The results for December are summarized in Table VII below.

Table VII: Results Summary for December

	December
Dry Concentrate Throughput – t/d	
- # 2 Reverb	371
- CT	523
- Total	894
Reverts – t/d	
- # 2 Reverb	280
Return CT + PS Slag - ladles/day	
- # 2 Reverb	23
Cu in Discard Slag - %	
- # 2 Reverb	0.87
Furnace Levels – inches	
- # 2 Reverb	8
Hearth Measurements - metres	
- # 2 Reverb	6.78

The performance of #2 furnace was better than expected in December, as it smelted more concentrates and reverts than in November (651 t/d, compared to 475 t/d), and treated 23 ladles/day of CT plus PS return slag, compared to 19 ladles/day in November. #2 furnace handled the slag-cleaning duties well. Average copper in slag was 0.87%, well within the target of < 1%. Furnace levels were well under control during the month, and the hearth remained stable.

CONCLUSIONS

The plant test-work carried out between August and December 2004 showed that a smelter throughput of around 900 t/d concentrates throughput was easily achievable with only one reverb furnace on line. The results indicated that, if the CT throughput was increased by a further 500 t/d to around 1 000 t/d, and concentrate to the reverb reduced to 250 t/d, that there was ample settling time available in one reverb, and that copper in slag could be maintained at < 1%. Above that level of throughput, the signs were that crane movements between the CT and reverb and slag handling from the reverb with the existing train system would become the bottlenecks.

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