

# Process description and optimization of the flash dryers at Polokwane Smelter

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*Polokwane Smelter*

Anglo Platinum's Polokwane Smelter is situated outside Polokwane, in the Limpopo Province of South Africa. Wet concentrate is received from various concentrators along the Eastern Bushveld Complex. Approximately 60% of the total concentrate received is from UG2 Reef, and 40% is from Merensky Reef. The concentrate is dried in two flash dryers, and smelted in a single 168 MVA furnace. A PGM-rich nickel-copper matte is cast, crushed and transported to Rustenburg for converting.

The plant was commissioned in March 2003.

The wet concentrate, containing 12–18% moisture, is weighed, sampled by one of two auger samplers, and off-loaded into a concentrate shed, either directly through a grizzly into a hopper, or onto the floor. From the shed the concentrate is conveyed to 12 concrete silos. Each of the two identical flash dryers can be fed from six silos. From the flash dryers concentrate is transported pneumatically to a 3 000-ton dry concentrate storage silo.

The flash dryers are rated at a nominal 66 tph of dry concentrate at 14% moisture, while the furnace can smelt 90 tph of dry concentrate. Therefore both flash dryers are required to operate when the furnace runs at design throughput.

Each flash dryer consists of a hot gas generator (HGG), a disintegrator and drying column, and a section for gas/solids separation.

In the HGG, gas heated up to 700° C is produced from the combustion of coal peas in a fluidized sand bed. The hot gas and wet concentrate are introduced to the disintegrator at the bottom of the drying column. The disintegrator breaks up any lumps of concentrate, and throws the concentrate up into the drying column, where it travels co-currently with the hot gas. A fan draws the hot gas from the drying column and through the gas/solids separation section, which consists of three primary cyclones, a multiclone and a high-temperature bag house. The dry concentrate reports to a 450-ton dry concentrate storage bin. A portion of dry concentrate is recycled to the wet concentrate feed in a paddle mixer, so that concentrate that is too wet does not enter the disintegrator.

The drying column outlet temperature is controlled at 120° C.

Coal is received by road, screened for oversize and conveyed to a 400-ton concrete silo. From here it is pneumatically conveyed to a small feed bin at each of the HGG's.

The optimization work consists of process control improvements relating to the HGG outlet temperature, to control the drying column temperature during the ramp-up of the HGG outlet temperature and bag filters.

Furthermore a heat balance is used to evaluate options to increase the instantaneous drying capacity of the existing equipment. The coal consumption derived from the heat balance is compared with the actual coal consumption.

The purpose of the optimization work is to achieve an operating schedule for the flash dryers such that they operate simultaneously for as short time as possible. Most of the time one flash dryer should operate, allowing maintenance to be done on the other flash dryer, while drawing down the dry concentrate stock.

*Keywords: Anglo Platinum, Polokwane Smelter, pyrometallurgy, metallurgy, platinum, platinum group metals (PGM), base metals, flash drying, fluidized bed.*

## Introduction

Polokwane Smelter is the only platinum-producing smelter on the eastern limb of the Bushveld Complex. The plant was commissioned in March 2003. Anglo Platinum's longer-term expansion plans include the development of several mines and concentrators on the eastern limb. The smelter was designed to treat the arisings from these concentrators.

Approximately 60% of the total concentrate received is from UG2 Reef and 40% is from Merensky Reef. The concentrate is dried in two flash dryers and smelted in a single 168 MVA furnace (Figure 1). A PGM-rich nickel-copper matte is cast, crushed and transported to Rustenburg for converting.

A previous paper (Nelson *et. al.*<sup>1</sup>) discusses the furnace

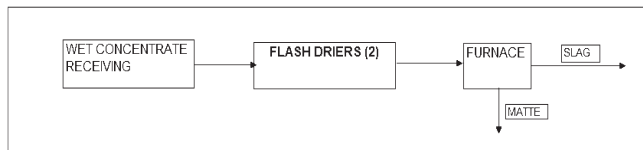


Figure 1. Polokwane smelter flow sheet

and smelting process, while this paper will focus on the flash dryers. The flash dryers were developed, designed and supplied by Drytech. The wet concentrate, containing 12%–18% moisture, is weighed, sampled by one of two auger samplers, and off-loaded into a concentrate shed, either directly through a grizzly into a hopper, or onto the floor. From the shed the concentrate is conveyed to 12 concrete silos with a capacity of 700–900 wet tons. Each of the two identical flash dryers can be fed from six silos by the flash dryer feed conveyor. From the flash dryers concentrate is transported pneumatically to a 3 000-ton dry concentrate storage silo.

The reason for the increased focus on the flash dryers is the fact that the furnace has been operating close to its design capacity, and smelts 90–100 t/hr. This has put more pressure on the flash dryers to supply sufficient dry concentrate. As the design capacity of one flash dryer is less than 90 t/hr, it is necessary to run both. However, the design capacity of both flash dryers is such that it should be possible to build up sufficient dry concentrate stock to stop one flash dryer for a couple of days for maintenance while the furnace and the other flash dryer continue to produce at full capacity. Therefore the challenge is to operate the flash dryers at design capacity and more.

### Flash dryer flow sheet

Each flash dryer consists of a hot gas generator (HGG), a disintegrator, drying column, and a section for gas/solids separation (Figure 2).

In the HGG gas heated up to 700° C is produced from the combustion of coal peas in a fluidized sand bed. The HGG maintains a fluidized bed temperature of 900° C by passing ambient air through the bed. The coal is introduced by three variable-speed horizontal screw feeders. The screw feeders are positioned on one side of the HGG. The coal is blown into the HGG by an air jet to promote an even distribution of coal in the fluidized bed. The temperature of the fluidized bed is measured by four thermocouples installed in the side wall at equal distance from each other. The average bed temperature is controlled at 900° C by varying

the coal screw feeder speed. Maximum designed coal flow rate to the HGG is 2.6 t/hr. Although the bed temperature is 900° C, the gas outlet temperature is less than 700° C, because cold air is sucked in through the stack and combined with the gas from the fluidized bed. The HGG outlet temperature is controlled by the damper position of the fluidizing air fan. The fluidizing air flow can go up to 10 m<sup>3</sup>/s. For start-up purposes four LPG burners have been installed. Start-up time from cold takes one to two hours.

For stand-by purposes there is a ‘caretaker mode’, which keeps the sand bed hot by periodically fluidizing the bed. In this way the flash drier is kept ready for immediate production without the need to use LPG. This reduces the consumption of LPG which is expensive.

Sand (98% SiO<sub>2</sub>) particle size is between 1 and 2 mm and the superficial air velocity goes up to 0.6 m/s. The sand bed is about 0.6 m thick.

The hot gas and wet concentrate are introduced to the disintegrator at the bottom of the drying column (which has a 1.5 metre internal diameter). The disintegrator acts like a hammer mill that breaks up any lumps of concentrate and throws the concentrate up into the drying column, where it travels co-currently with the hot gas. An exhaust fan draws the hot gas from the drying column through the gas/solids separation section. This comprises three primary cyclones, a multiclone and a high-temperature bag plant. The primary cyclone underflow box contains a grid to catch tramp material like gloves and pieces of bag. The multiclone consists of 140 small cyclones. The bag plant has four bag houses, each with four compartments. Each compartment contains 200 bags, providing a total filtration surface area of 3 584 m<sup>2</sup> for each flash dryer. The maximum design gas flow rate is 41 Am<sup>3</sup>/s. Pulsing is done off-line by closing the inlet damper to each compartment in turn. Concentrate is removed from each bag house by a screw feeder. In the original design a pneumatic low-density transport system, separated from the bag house by a rotary vane feeder, transferred the concentrate from the bag houses to a product storage bin. However this system has been replaced by a high-density transport system, as the rotary vane feeders did not provide a good air seal and required frequent replacement. In the first half of 2005 the high-density transport system was installed on two of the bag houses of flash dryer 2, and during a shut-down in July 2006 the same system was installed on the other six bag houses.

The dry concentrate reports to a 450-ton product storage bin. Up to 30 t/hr of dry concentrate is recycled to the wet concentrate feed in a paddle mixer, to keep the moisture in the concentrate entering the disintegrator below 10%. Two high-density transfer systems, each consisting of a 4-ton measuring vessel and a transfer vessel, transfer the concentrate to a 3 000-ton dry concentrate storage bin. In the original design screw feeders transferred concentrate into the measuring vessels, but the screw feeders have been replaced by air slides which require hardly any maintenance

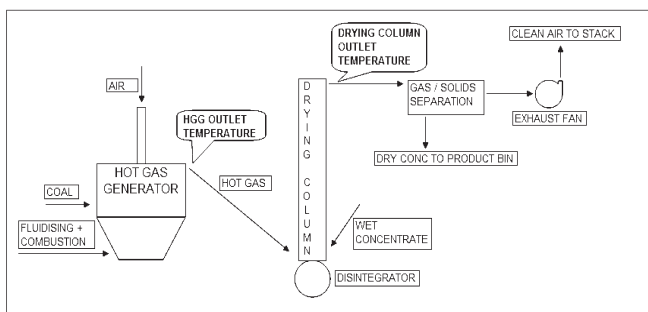


Figure 2. Flash dryer flow sheet

Table I  
Flash dryer plant specification.

Capacity	66.2	Dry ton/operating hour
Average feed moisture	14 %	Mass/mass
Capacity, daily	1847	Wet tons/24 hour operation
Maximum design wet feed rate	78.5	ton/hour at 16 % moisture
Evaporation rate range	6.0 to 12.3	Ton of water/hour
Heat release, design	64	GJ/hr
Heat release, operating	54	GJ/hr
Availability	90	%

and do not leak, as the screw feeders did.

The drying column outlet temperature, as measured in the outlet duct from the primary cyclones, is controlled at 120° C by varying the wet concentrate feed rate.

Coal is received by road, screened for oversize and conveyed to a 400-ton concrete silo. From there it is pneumatically conveyed to a small feed bin at each of the HGGs.

The flash dryer plant specification is given in Table I. It should be possible to achieve the daily capacity of 1 847 wet tons/day per flash dryer if no maintenance is required, as the average moisture of concentrate received is between 13.5%–15.0%.

### Flash dryer operation

Some flash dryer throughput data for August 2005, February 2006 and the first 16 days of March 2006 are given in Table II below. August 2005 was chosen because during that month an attempt was made to operate the furnace at full power for the whole month.

Flash dryer 2 generally performs better than flash dryer 1 because it has more effective solids removal from the bag houses because the high-density transport system had already been installed on two of its bag houses. Insufficient solids removal from the hopper below a bag house results in the hopper filling up. If the hopper is full, the bag house is taken off-line automatically until the hopper is empty. If one or two bag houses are off-line, the throughput is reduced because the gas flow through the drying section is restricted. If three out of four bag houses are off-line the hot gas generator is taken off-line, and drying stops completely. For this reason flash dryer 1 has significantly more down time and operating time at reduced throughput than flash dryer 2. This explains the higher down time but still higher

throughput for flash dryer 2 compared with that of flash dryer 1 in August 2005.

Another reason for down time on both flash dryers 1 and 2 was the wet concentrate feed chute which blocked every three hours and required off-line cleaning in order to do the job safely.

As can be seen from Table II, the daily average throughput, and even the daily maximum throughput, do not come close to the design capacity of 1847 t/d. The results fall also short of what was achieved by flash dryer 4 at Waterval Smelter in May 2006. (See Table III.) Flash dryer 1 and 2 at Polokwane Smelter are identical to flash dryer 4 at Waterval Smelter.

Improvements to the flash dryer operation to bring the actual daily throughput closer to the design throughput are discussed in the section below.

### Improvements to flash dryer operation

Improvements were investigated along two lines:

- improvements that could be implemented quickly for quick results (feed chute and process control)
- a more fundamental analysis by doing a heat balance to identify opportunities for increasing throughput.

### Improvements implemented

The following quick improvements on feed chutes and process control were implemented.

- 1 Feed chutes:** Blocking of the feed chute was resolved by hanging chains in the feed chute, so that the concentrate falls against the moving chains instead of the side wall of the chute. Cleaning of the feed chute is no longer required, and down time is no longer incurred for this reason.
- 2 Bag Houses on/off-line:** When the hopper below a bag house gets full, the process control system takes this bag house off-line to allow the hopper to empty. However when the hopper has been emptied, the bag house does not come online automatically, but has to be put online by the operator. As the control room operator does not have time to watch the bag houses continually, throughput was being lost because bag houses were off-line unnecessarily. Therefore this function was automated to enable a bag house to come online 30 minutes after it went off-line, if the hopper is empty (i.e. the level probe is healthy). The minimum off-line period of 30 minutes prevents the bag house from toggling on and off line if the material is just touching the level probe.
- 3 Ramp up rate of hot gas generator:** If a flash dryer stops for any reason (for example an interruption of feed, drying column temperature too high or too low, maximum HGG outlet temperature exceeded), it will re-start automatically if conditions return to normal. However the heat output from the hot gas generator could rise much faster than the feed control could increase the wet concentrate feed rate. Consequently the drying column outlet temperature would exceed its maximum of 135° C and the flash dryer would stop again. This could go on ten times before an operator would intervene. To alleviate this problem the ramp-up rate of the HGG was halved, so that it would match the increase in feed rate better.
- 4 Automatic control of HGG outlet temperature at maximum:** Drying capacity is maximized if the heat

**Table II**  
Daily average and maximum wet tons fed to each flash dryer and down time for August 2005, February 2006 and the first 16 days of March 2006

MONTH	AUG 2005		FEB 2006		MARCH 2006	
Average moisture of concentrate received (%)	15.3		14.6		14.8	
FD 1 or FD 2	FD 1	FD 2	FD 1	FD 2	FD 1	FD 2
Average (t/d)	981	1019	841	1196	1095	994
Average down time per day (hrs)	3.6	5.9	7.9	3.7	5.1	5.5
Maximum (t/d)	1439	1557	1210	1578	1455	1595
Down time at max (hrs)	0.9	0.6	1.4	0.6	1.0	0.1

**Table III**  
Daily average and maximum wet tons fed to flash dryer 4 at Waterval Smelter for May 2006

MONTH	MAY 2006
Average moisture of concentrate dried (%)	17.6
Average (t/d)	1412
Average down time per day (hrs)	4.2
Maximum (t/d)	1690
Down time at max (hrs)	1.8

output from the HGG is maximized. That means that the HGG outlet temperature must be as high as possible. The HGG outlet temperature is controlled by the fluidizing air flow, and thus by the damper position of the fluidizing air fan. The original situation was that the operator entered a set point for the damper position. The control system would then slowly move the damper to this set point, as opening the damper too fast would result in loss of temperature in the fluidized bed. The damper would then remain at its set point regardless of the HGG outlet temperature. Usually this resulted in less than maximum heat output, and thus a lower drying rate.

An additional control loop was introduced to open the fluidizing air damper more (subject to a maximum) if the HGG outlet temperature was lower than the lower control limit, and to close the damper if the HGG outlet temperature was higher than the upper control limit. This control loop allowed control of the HGG outlet temperature close to its maximum of 700° C, thus maximizing both the heat output and the drying rate.

## Results

As a consequence of implementation of the above process control improvements, new daily drying records were set in April 2006. From Table IV it can be seen that both flash dryer 1 and 2 achieved the design capacity of 1 847 wet tons/24 hours operating time, taking into account the down time. Although the moisture content of the wet concentrate dried on these particular days is not known, the average moisture in concentrate received for April 2006 was 13.7%, which is only 2% lower than the design of 14%.

It can also be concluded that daily design capacity is not achieved every day. There are still delays caused by blockages in the wet concentrate storage bins and the offloading bins. In the short term, the planning of cleaning work needs to be improved, and suppliers of concentrate should avoid sending concentrate with more than 16% moisture. In the longer term, engineering modifications are planned to prevent blockages.

**Table IV**  
New daily drying records set in April 2006

FLASH DRYER 1			FLASH DRYER 2		
DATE	Wet Conc Dried Ton/day	Down Time Hours	DATE	Wet Conc Dried Ton/day	Down Time Hours
9 April	1789	0.9	5 April	1727	0.5
			14 April	1754	0.1
			15 April	1848	0.1
			17 April	1772	0.5

**Table V**  
Operating schedule for flash dryers

DAY	CONC DRIED		CONC SMELTED	DRY CONC STOCK
	FD 1	FD 2		
0				3600
1	1589	0	2160	3029
2	1589	0	2160	2458
3	1589	0	2160	1887
4	1589	0	2160	1316
5	1589	0	2160	745
6	1589	1589	2160	1763
7	1589	1589	2160	2781
8	1589	1589	2160	3799
9	0	1589	2160	3228

If the daily flash dryer design throughput would be achieved consistently, the operating schedule shown in Table V should be possible, assuming that the furnace smelts 2 190 dry t/day and a flash dryer produces 1 589 dry t/day.

Table V shows that one flash dryer operating for five days and two flash dryers operating simultaneously for three days could maintain the dry concentrate stock while the furnace smelts at full capacity. After eight days a flash dryer would be off-line for five days for maintenance.

## Heat balance

A heat balance for the flash dryer was calculated with the following objectives:

- to assess the energy flows in the drying process
- to assess the difference in efficiency between operating at low and high throughput
- to assess the impact of outside air temperature
- to assess the opportunities for further increases in drying rate.

### Calculation of heat balance

The heat balance has been calculated from basic principles in an Excel spreadsheet. The following assumptions were made:

- net calorific value of coal is 26.5 MJ/kg
- HGG bed temperature is 900° C
- all coal is combusted
- outside air temperature and concentrate temperature are 20° C
- drying column outlet temperature is 120° C.

The reference temperature is 25° C. First a heat balance for the hot gas generator is done, then repeated for the drying column. The enthalpy changes of gases are calculated using empirical equations for heat capacity at constant pressure from the *Handbook of Chemistry and Physics*<sup>2</sup>. The enthalpy changes of solids are calculated using data from Rosenquist<sup>3</sup>.

The heat balance for the HGG is worked out as follows. First the heat generated from coal combustion in the fluidized bed is calculated, adjusting the volume of fluidizing air to get a bed temperature of 900° C. The coal spreader air is constant at 7 t/hr. The gas leaving the fluidized bed is then mixed with cold air sucked in through the HGG stack. The volume of cold air and the HGG outlet temperature are adjusted so that the energy leaving the fluidized bed is the same as the energy leaving the HGG in the gas to the drying column.

The heat balance for the drying column is worked out as follows. The hot gas from the HGG comes into contact with wet concentrate in the drying column. The heat in the gas from the HGG is absorbed by the evaporation of water, heating of the concentrate, and cooling of the gas and ash. The heat output from the drying column is balanced with the heat input by adjusting the wet concentrate flow and the moisture in the concentrate. It is assumed that all the material and gas leave the drying column at 120° C.

The recycle stream of dried concentrate does not have an impact on the heat balance, as it is assumed that the dried concentrate recycled to the wet concentrate feed has the same temperature as the dried concentrate leaving the drying column.



**Table VII**  
Heat balances of HGG for drying 77.0 wet t/hr at 0° C and 20° C

Outside air temperature (° C)	0	20
Wet concentrate feed (t/hr)	77.0	77.0
Coal flow (t/hr)	1.65	1.61
Energy from coal (MW)	12.2	11.8
Moisture in concentrate (%)	14.0	14.0
Moisture evaporated (t/hr)	10.8	10.8
Coal consumption (kg/t evaporated)	153	149
% of heat input used for evaporation	64.9	66.7

## Results of heat balance calculations

### Difference in efficiency between operation at low and high throughput

The heat balances for drying at 38.5 wet t/hr and 77 wet t/hr (equivalent to design capacity of 66.2 dry t/hr) are given in Table VI below.

The calculated coal flow of 1.61 t/hr when drying at 77 t/hr is close to the measured value of 1.6 t/hr –1.7 t/hr.

From Table VI it can be concluded that drying at a high rate is more efficient than drying at a low rate, as the coal consumption per ton of water evaporated is 8% higher when drying at low rate. This was expected, as less air per ton concentrate must be heated when drying at a high rate.

The electrical power consumption of a flash dryer is about 1 MW, regardless of drying rate. Therefore both electrical power and coal consumption per ton of concentrate dried are lower when drying at a higher rate.

### Impact of outside air temperature

The outside air temperature in Polokwane ranges from 0° C on a winter night to above 30° C on a summer day. As the air and concentrate are heated to 120° C only, a 30° C change in outside air temperature could have a relatively large impact on throughput or the amount of coal required. To assess the impact of outside air temperature two heat balances were done drying 77.0 wet t/hr: One with an outside air temperature of 0° C, and one with an outside air temperature of 20° C. As the damper position of the exhaust fan and the gas temperature after the drying column remain the same, the gas flow through the drying column remains the same. Therefore the heat balance for the drying column is the same for both cases, and only the difference in the heat balance of the HGG is looked at.

From Table VII it can be seen that at an outside air temperature of 0° C the coal consumption is 2.8 % higher (1.65 t/hr versus 1.61 t/hr) than at an outside air temperature of 20°. Alternatively, throughput would be 2.8% or 2.2 wet t/hr lower. Therefore outside air temperature has a significant impact.

**Table VI**

Heat balances for drying at 38.5 wet t/hr and 77.0 wet t/hr (MW)

Wet concentrate feed (t/hr)	38.5	77.0
Coal flow (t/hr)	0.86	1.61
Energy from coal (MW)	6.3	11.8
Moisture in concentrate (%)	14.0	14.0
Moisture evaporated (t/hr)	5.4	10.8
Coal consumption (kg/t evaporated)	160	149
% of heat input used for evaporation	62.4	66.7
HEAT BALANCE DRYING COLUMN:		
HEAT INPUT (MW):		
Heat in gas from HGG	6.3	11.8
HEAT OUTPUT (MW):		
Gas from HGG leaving drying column	1.1	1.7
Evaporation and heating of moisture	3.9	7.9
Heating of concentrate to drying temp.	0.9	1.8
Heat losses	0.4	0.4
TOTAL HEAT OUTPUT	6.3	11.8

### Potential to increase throughput

Throughput could be increased in the following ways:

- decrease drying column outlet temperature
- increase HGG outlet temperature from 660° C to 670° C
- increase coal combustion rate to dry 90 wet t/hr.

Decreasing the drying column outlet temperature assumes that the energy now not leaving the drying column with the air can be absorbed by drying more concentrate. However, a lower drying column outlet temperature would increase the risk of acid dew point corrosion. Therefore this option has not been pursued any further.

For the case of increasing of the HGG outlet temperature from 660° C to 670° C, it is assumed that the gas flow through the drying column remains the same. The heat balance for this case is given in Table VIII.

From Table VIII it can be seen that the throughput can be increased from 77.0 wet t/hr to 79.2 wet t/hr, which is a meaningful increase. This shows that the HGG outlet temperature should be operated as close as possible to its maximum of 700° C without running the risk of exceeding it and tripping the flash dryer.

Increasing coal combustion rate to dry 90 wet t/hr assumes that the inlet damper of the exhaust fan is opened further to increase the gas flow through the drying column. The heat balance for this case is given in Table IX.

The fluidizing air flow would increase from 34.6 t/hr to 41.3 t/hr, which is still well below maximum design of 65 t/hr. The total gas flow through the drying column would increase from 24 Am<sup>3</sup>/s to 28 Am<sup>3</sup>/s, well within the maximum design of 41.7 Am<sup>3</sup>/s for both the exhaust fan

**Table VIII**

Heat balances for drying at an HGG outlet temperature of 660° C and 670° C

HGG outlet temperature (° C)	660	670
Wet concentrate feed (t/hr)	77.0	79.2
Coal flow (t/hr)	1.61	1.65
Energy from coal (MW)	11.8	12.1
Moisture in concentrate (%)	14.0	14.0
Moisture evaporated (t/hr)	10.8	11.1
Coal consumption (kg/t evaporated)	149	148
% of heat input used for evaporation	66.7	67.1
HEAT BALANCE DRYING COLUMN:		
HEAT INPUT (MW):		
Heat in gas from HGG	11.8	12.0
HEAT OUTPUT (MW):		
Gas from HGG leaving drying column	1.7	1.7
Evaporation and heating of moisture	7.9	8.1
Heating of concentrate to drying temp.	1.8	1.8
Heat losses	0.4	0.4
TOTAL HEAT OUTPUT	11.8	12.0

**Table IX**  
Heat balances for drying 77 wet t/hr and 90 wet t/hr

Wet concentrate feed (t/hr)	77.0	90.0
Coal flow (t/hr)	1.61	1.87
Energy from coal (MW)	11.8	13.7
Moisture in concentrate (%)	14.0	14.0
Moisture evaporated (t/hr)	10.8	12.6
Coal consumption (kg/t evaporated)	149	148
% of heat input used for evaporation	66.7	67.3
HEAT BALANCE DRYING COLUMN:		
HEAT INPUT (MW):		
Heat in gas from HGG	11.8	13.6
HEAT OUTPUT (MW):		
Gas from HGG leaving drying column	1.7	1.9
Evaporation and heating of moisture	7.9	9.2
Heating of concentrate to drying temp.	1.8	2.1
Heat losses	0.4	0.4
TOTAL HEAT OUTPUT	11.8	13.6

and the bag plant. Therefore it is realistic to operate the flash dryer at 90 t/hr, if there is no restriction on materials handling at that throughput, and if the drying column has sufficient volume to allow the heat transfer to take place.

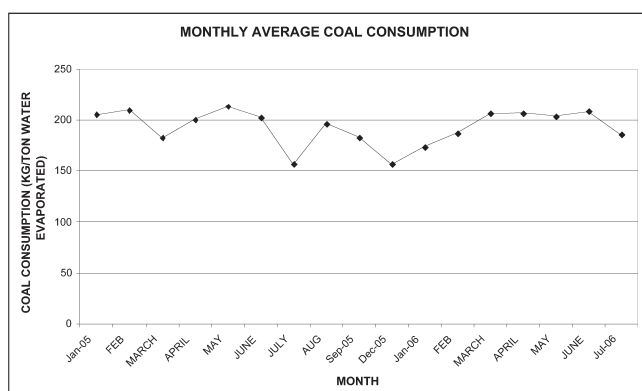
Drying at 90 t/hr has not yet been tried, as the dust removal from the bag houses was governed by a materials handling restriction. However at the end of July high-density transfer systems will have been installed on all bag houses, so that this restriction will have been removed.

It can be concluded that increasing coal combustion rate and gas flow through the drying section is potentially the most effective way of increasing throughput and maximizing utilization of installed drying capacity.

### Actual operating performance

Figure 3 shows a graph of the monthly average coal consumption per ton of water evaporated from Jan 2005. The data were compiled using monthly concentrate closing stocks and monthly average moistures of concentrate received. As considerable stockpiling took place during 2005 and 2006, there is not always a direct correlation between concentrate received during a month and concentrate processed during a month, resulting in some inaccuracy. However the data can still be used for comparison with theoretical data.

For October and November 2005 there are no data, as the



**Figure 3. Monthly average coal consumption for 2005 and 2006, Jan–July**

furnace was down for those two months.

According to the heat balance data, coal consumption should range from 149 kg/t–160 kg/t water evaporated. Actual data range from 160–210 kg/ton water evaporated, while the weighted average for 2006 is 196 kg/ton water evaporated. Two reasons for the difference are:

- the incorrectness of the assumption that all coal is combusted
- flash dryer down time and variations in throughput.

According to Perry<sup>4</sup> 5–10% of coal combustion efficiency is lost because of carry-over of unburned particles, and to a lesser extent because of incomplete combustion to carbon monoxide. As the total difference in coal consumption is about 30%, a significant part of the difference must be caused by the fact that the flash dryer does not always operate at full capacity, but also spends time on hot stand-by and stopping and starting. This shows that continuous operation at maximum design is a key factor to achieve the efficiency predicted by the heat balance.

### Conclusions

Successful feed chute and process control improvements have been described. It can be concluded that:

- the Polokwane Smelter flash dryers can run at their daily design throughput after the implementation of these changes
- it is possible to run the Polokwane furnace at full capacity operating alternately two flash dryers simultaneously or one flash dryer, allowing planned maintenance to be done on the flash dryer that is not required to operate

The actual daily average throughput is still well below the daily design throughput, leading to the conclusion that at this stage the biggest scope to increase daily throughput and efficiency is to ensure continuous operation at design drying rate.

The heat balance work showed that the impact of changes in outside air temperature and changes in HGG outlet temperature on throughput are meaningful, and instantaneous throughput can be increased beyond the design of 77 wet t/hr to at least 90 wet t/hr.

### Literature

1. NELSON, L.R., STOBBER, F., NDLOVU, J., DE VILLIERS, L.P.S. and WANBLAD, D. Role of technical innovation on production delivery at Polokwane Smelter, *Nickel and Cobalt 2005: Challenges in Extraction and Production*, 44th Annual Conference of Metallurgists, Calgary, Alberta, Canada. 21–24 Aug 2005, pp. 91–116
2. *CRC Handbook of Chemistry and Physics*, CRC Press, 63rd edition, 1982–1983
3. ROSENQUIST, T. *Principles of Extractive Metallurgy*, McGraw-Hill Book Company, 2nd edition, 1983.
4. *Perry's Chemical Engineers' Handbook*, McGraw-Hill Book Company, 6th edition, 1984.
5. HUNDERMARK, R., DE VILLIERS, B. and NDLOVU, J. Process description and short history of Polokwane Smelter, Southern African Pyrometallurgy 2006 International Conference, Cradle of Humankind, South Africa, 5–8 March 2006.