Leeuwpan fine coal dense medium plant

by M. Lundt* and G.J. de Korte†

Synopsis

Exxaro installed their first ultra fines treatment plant at Leeuwpan Coal mine. The plant is now fully operational and results already show that the plant has great potential. The plant was designed and installed by DRA. Several challenges were faced during the installation due to the space constraints in the Leeuwpan plant. Efficiency tests were conducted on both modules after commissioning and showed very promising results. A lower ash product with a higher yield can be produced with the fine coal dense medium cyclones compared to the spirals previously employed.

Keywords

Leeuwpan, dense medium cyclones, fines beneficiation, magnetic separators, high yield.

Introduction

Leeuwpan Colliery is located close to Delmas in the Mpumalanga Province, and is one of eight coal mines in the Exxaro Resources group.

The dense media separation (DMS) plant at Leeuwpan was commissioned in 1997. The plant originally treated three Witbank coal seams, namely seams no. 2, 4 and 5. A coal jig plant was built in 2005 to treat the top layer of coal—Seams 4 and 5—to supply a 30% ash coal to power stations. When the jig plant was commissioned, it increased the DMS plant availability to treat the higher grade coal (the bottom layer of coal) from the no. 2 Seam for a local and export metallurgical market.

Following the path of evolution, in 2007, Leeuwpan commissioned the first double stage ultra-fines dense medium cyclone plant in the coal industry, to form part of its overall DMS plant. It replaced the spirals to treat the -1 mm material. Spirals are still the most commonly and accepted method used by the industry, but it seems as if the pioneering cyclone process has ignited interest among many players in the industry (Theunissen, 2008).

The Leeuwpan plant consists of two identical modules. In each module there are two 800 mm cyclones to beneficiate the 6 x 25 mm and the 1 x 6 mm material, respectively. The +25 mm feed of both the modules is directed into a Wemco drum, whereas the -1 mm material was beneficiated by spirals in each module before the fine dense medium circuit was installed.

The business case for the fine dense medium circuit was based on the fact that a better quality product can be produced at a higher yield, and the quality can also be controlled to a fixed RD set point, something that is difficult to achieve with spirals.

Leeuwpan's fines dense medium process

The fines dense medium circuit was installed by DRA, in the same area previously occupied by the spirals. Each module in the DMS plant has its own fines dense medium circuit, with some of the equipment from the spiral plant, such as tanks, pumps and dewatering screens being reused in the new installation.

The process flow shown in Figure 1 is described as follows:

- The -1 mm feed material enters a hydrocyclone, which performs a desliming function by removing the -100 micron particles which are dispensed to the thickener.
- The +100 micron to -1 mm material gravitated to a feed dewatering screen. The feed material after the dewatering screen is mixed with magnetite in a launder and then pumped to a primary cyclone (the first stage beneficiation).
- The primary cyclone overflow is again

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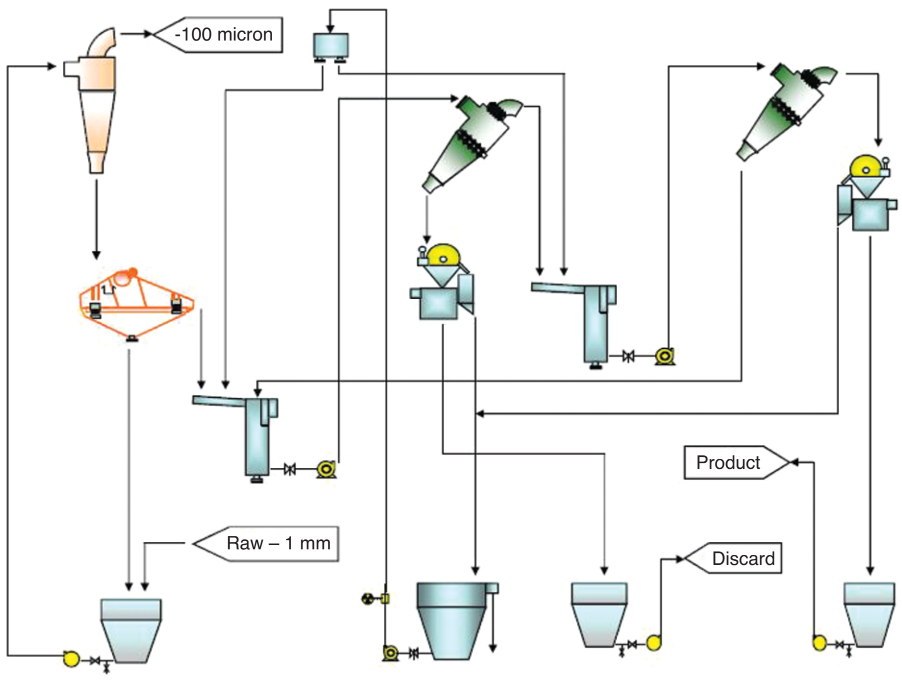

Figure 1—Flow diagram of the fine coal dense medium circuit at Leeuwpan (de Korte, 2008)

mixed with magnetite in the launder and enters a second stage washing cyclone.

- The product of the secondary cyclone is sent to a product magnetic separator and the discard of the primary cyclone is routed to the discard magnetic separator.
- The discard of the secondary washing stage is recycled back to the feed.
- The product and discard (underflows of the magnetic separators) are deslimed and dewaterered on product and discard dewatering screens once again and transported to the product and discard conveyors.

Installation and operation difficulties

Fitment of new plant into the existing circuit

The biggest challenge with the plant design and installation was to fit the new plant into the space where the spirals used to be, given the equipment size and the pipe work between the equipment. As can be seen in Figures 2, 3 and 4 there was very limited space for installation, but DRA excelled with the design and layout of the plant, and therefore the entire effect on installation was done with minimum production loss due to a temporary bypass line that was installed to divert the -1 mm material feed straight to a dewatering screen while the rest of the plant was under construction.

Remarkably therefore, the entire installation was done while the rest of the plant continued with production.

Plant equipment operational changes

Cyclone spigot changes

In an attempt to lower the cut-point density, the spigot on the

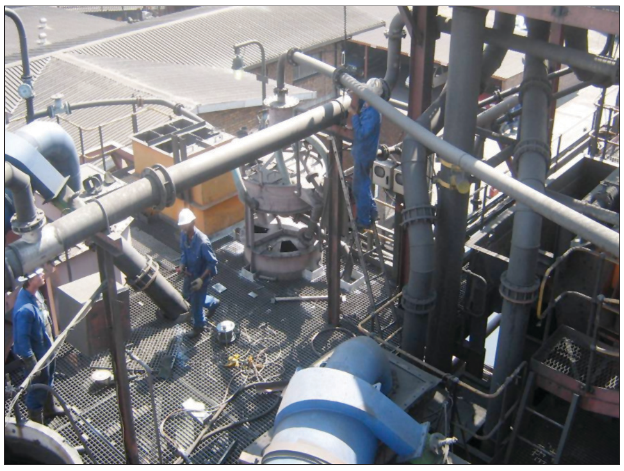

Figure 2—Leeuwpan fines plant under construction

Figure 3—Confined spaces for installation

Figure 4—Primary and secondary dense medium cyclones

primary cyclone was increased from 120 mm to 145 mm and that of the secondary cyclone from 100 mm to 120 mm. A series of tests was conducted on 1 November 2007 to evaluate the performance of the cyclones with the larger spigots. The circulating medium density was lowered progressively and samples of the feed, product and discard were taken at each of the 4 different density settings. Bottom coal was being processed at the time (de Korte, 2008). The results obtained are shown in Table I.

The results show that the circulating medium density needed to be lowered to 1.25 in order to obtain a product with 15% ash. This is not unusual, as similar results were obtained on the Coaltech pilot plant.

The product ash is directly related to the density of the circulating medium as shown in Figure 5. When the circulating medium density is increased, the density of the feed to both the primary and secondary cyclones is increased, and relatively small increases in the circulating medium density causes fairly large increases in the feed density to the two cyclones (de Korte, 2008).

Magnetite circulation and magnetite bleed stream

The efficient magnetic separators used on the fines plant can be considered an important breakthrough in ensuring stability in the ultra fines beneficiation circuit. High magnetite consumption in ultra fines beneficiation circuits has historically been viewed as problematic. The magnetic separators act as the drain and rinse screens of this process. The efficient magnetic separators ensure that minimum magnetite will report to the product or discard that goes to the desliming sections. Efficiency tests were done on the magnetic separators installed at Leeuwpan.

The results obtained from the analysis of the magnetic separator feed, over-dense and effluent samples show that the magnetic separators are working very well. Tables II and III summarize the results obtained.

Based on the above results, the calculated magnetite consumption is approximately 1.3 kg per feed tonne. The mine has thus far experienced magnetite consumption in this range and no significant increase in overall plant magnetite consumption was experienced. A photograph of the product magnetic separator in Module 1 is shown in Figure 6 (de Korte, 2008).

Table I

Test results 1 Nov 08 (de Korte, 2008)

Circ med RD	Feed ash, %	Product ash, %	Discard ash, %	Yield, %
1.30	28.7	15.8	68.3	75.4
1.30	28.4	15.9	68.2	76.2
1.25	29.6	15.0	61.8	68.8
1.25	29.0	14.7	63.8	70.8
1.20	35.6	13.3	63.8	55.8
1.20	27.5	13.3	62.7	71.1
1.18	26.5	12.3	50.6	62.8
1.18	26.2	13.1	52.8	67.2

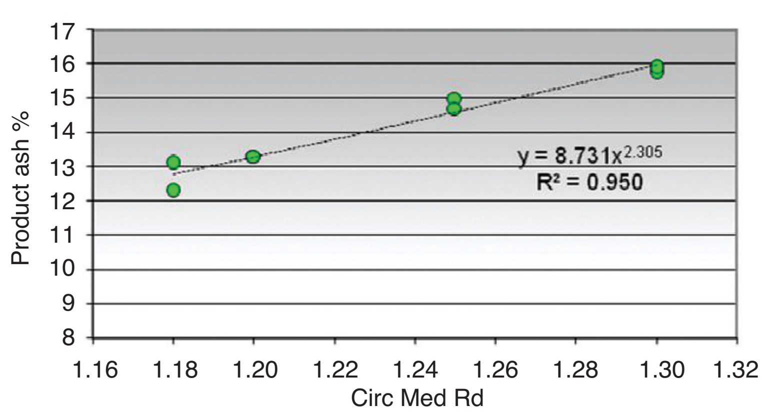

Figure 5—Relation between circulating medium density and product ash for Bottom coal (de Korte, 2008)

One modification was done to bleed magnetite into the fines plant instead of pumping raw magnetite form the make-up plant. A magnetite bleed line with a valve was installed from the course module next to the fines plant. The magnetite in the bleed comes from the underflow of the sieve bend, before the product drain and rinse screen. The modification presented two solutions: (a) to get magnetite easily and quickly into the fines plant for production and (b) to get very fine magnetite into the fines plant. The fine magnetite can assist in the separation in the cyclones. The magnetite bleed stream goes straight into the circulating medium tank of the ultra fines plant.

No problems were experienced with the build-up of coal in the medium circuit during the test campaign. Figure 7 illustrates that the non-magnetic fraction increases to a certain level before remaining constant (van der Merwe *et al.*, 2007).

Table II

Product magnetic separator performance (de Korte, 2008)

Product		04-Oct-07	14-Feb-08
Feed	g/L magnetite	189.10	156.64
Concentrate	g/L magnetite	1046.22	1016.38
Tailing	g/L magnetite	0.13	0.23
Efficiency	%	99.94	99.87

Table III

Discard magnetic separator performance (de Korte, 2008)

Discard		04-Oct-07	14-Feb-08
Feed	g/L magnetite	297.68	244.59
Concentrate	g/L magnetite	2038.24	1611.15
Tailing	g/L magnetite	0.08	0.15
Efficiency	%	99.98	99.95

Figure 6—Product magnetic separator (de Korte, 2008)

Water flow and stability in the plant

The water supply to both modules was from the main water supply line to the DMS plant. This line enters a manifold that distributed the water to the different places in the fines plant. For stable operation of the fines plant, constant water pressure is required. During commissioning several stability problems were encountered as a result of pressure drops in the line, when other valves were opened elsewhere in the DMS plant. To overcome this, a single line for the water supply of the density control was installed. The minimum and maximum levels of the circulating medium tank were set very close to each other so as to prevent the water of the level control to influence the medium density.

Plant control and instrumentation

The plant was designed to be automatically controlled from a Scada system in the control room. In order to do that a lot of instrumentation like automatic valves, density gauges and level probes had to be installed.

Results and efficiency

First efficiency test—October 2007

On 4 October 2007, the first efficiency test was conducted on the module 1 plant. Samples of the feed to plant, as well as the product and discards were collected and dispatched for analysis. Table IV reports the medium densities maintained during the test and the cyclone feed pressures. Top coal was being processed at the time of resampling the feed, product and discard (de Korte, 2008).

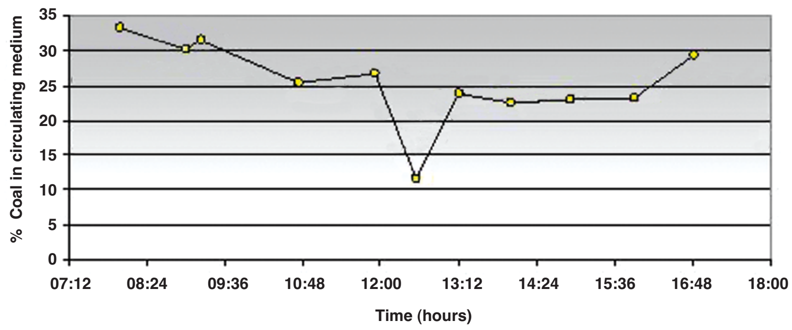

Figure 7—Non-magnetic material in circulating medium (Van der Merwe *et al.*, 2007)

Table IV

Operating densities and pressures (de Korte, 2008)

	Relative density	Feed pressure (kPa)
Circulating medium	1.21	
Primary cyclone feed	1.30	117
Secondary cyclone feed	1.18	121

Table V

Efficiency test results, October 2007 (de Korte, 2008)

Parameter	Value
Feed, % ash	36.4
Product, % ash	26.3
Discard, % ash	86.8
Product Yield, %	83.3
D50 cut-point density	1.998
EPM	0.0064
Organic efficiency, %	98.5
Sinks in float, %	11.05
Floats in sink, %	0.56
Total misplaced, %	11.61

Table VI

Operating densities and pressures 14 February 2008 (de Korte, 2008)

	Relative density	Feed pressure (kPa)
Circulating medium	1.30	
Primary cyclone feed	1.37	120
Secondary cyclone feed	1.25	121

Table VII

Efficiency test results February 2008 (de Korte, 2008)

Parameter	Value
Feed, % ash	21.7
Product, % ash	16.0
Discard, % ash	51.5
Product, yield %	84.0
D50 cut-point density	1.902
EPM	0.0620
Organic Efficiency, %	95.3
Sink in float, %	2.46
Float in sink, %	4.96
Total misplaced, %	7.42

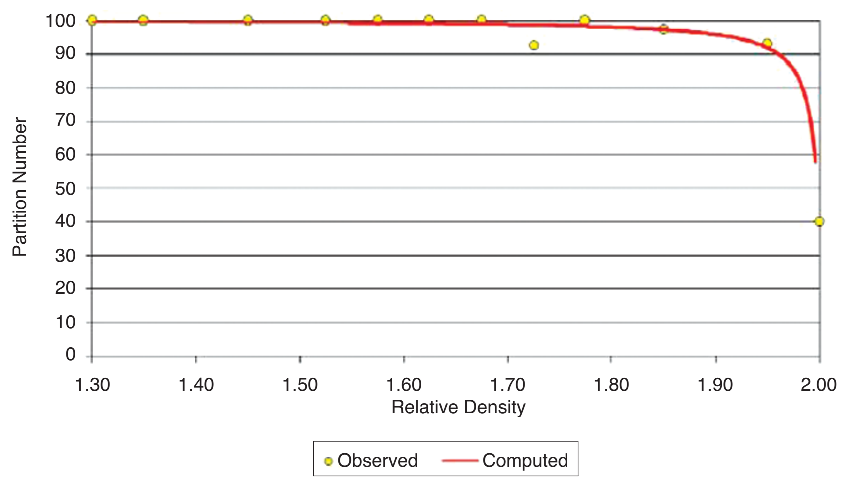

Figure 8—Partition curve, October 2007 (de Korte, 2008)

The results obtained (Table V) show that the cut-point density was extremely high, despite quite low cyclone feed densities. This is supported by the high yield and product ash. The high amount of misplaced sinks in the float seems to support the notion that the spigot could not handle the sinks. The partition curve (Figure 8) shows this graphically (de Korte, 2008). Prior to the second test, the spigot size of the primary and secondary cyclones were changed.

Second efficiency test

A second efficiency test was conducted on module 2 on 14 February 2008. The same sampling procedure as in the first test was used, and the samples were sent for analysis. Lean coal was being processed at the time of the test and the operating conditions during the test are shown in Table VI.

The results obtained from the samples taken are shown in Table VII. The partition curve for the separation is illustrated in Figure 9.

The results obtained again indicated a high cut-point density. This time though, the high cut-point density was largely due to the relatively high circulating medium density. The product ash (16%) corresponds to ash obtained at the same circulating medium density during the 1 November tests. The EPM and organic efficiency values obtained were quite acceptable and the amount of misplaced material is normal for -1 mm material (de Korte, 2008).

Conclusion

The commissioning of both fines modules at Leeuwpan presented great challenges but ultimately there is a wonderful success story to tell at the end of the project.

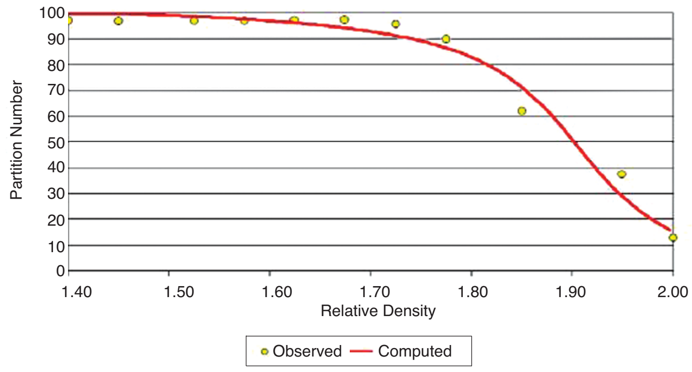

Figure 9—Partition curve February 2008 (de Korte, 2008)

Both these modules run at full capacity and are able to produce to product specifications for prolonged periods. The investment in the project by Exxaro has already been recovered from the additional sales tonnes generated by the fines plants.

Continuous improvement and process optimization of the plants will be required, given that Exxaro is presently considering and investigating the installation of fines dense medium plants in other operations.

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Nielen van der Merwe addressing delegates at a recent conference in India

President elect of the SAIMM, Prof Nielen van der Merwe, has recently been elected to two important positions in the international mining and geotechnical community

He is now chairperson of the Uranium Production Network (UPNet) Advisory Committee of the International Atomic Energy Agency of the United Nations and chairman of the board of the Federation of International Geo-Engineering Societies (FedIGS).

The UPNet was created by the IAEA of the UN to facilitate contact between uranium producers and technical advice entities. The need for UPNet arose from the realization that renewable energy sources will not supply all the energy the world needs, and that economically viable fossil fuel resources are approaching depletion and are subject to severe resistance from environmentalists.

It is projected that the world will construct more nuclear power plants and therefore an increasing need for uranium is foreseen. It is expected that uranium will be mined in countries without a strong mining presence and consequently it is necessary to create a mechanism for new mines to make contact with people and groups with mining expertise.

The FedIGS was created in 2008 as an umbrella organization covering three international societies that focus on geotechnical issues. The three founding member societies are the International Society for Rock Mechanics (dealing mostly with rock engineering, and of which Nielen was President during the period 2003 to 2007), the International Society for Soil Mechanics and Geotechnical Engineering (dealing mostly with foundation issues) and the International Association for Engineering Geology and the Environment.

All three societies are non-profit learned societies. The eventual creation of FedIGS was the result of several years of negotiation as all three societies had to approve constitution amendments at their annual council meetings. The organization mainly aims to be the single voice of geotechnical experts world-wide, representing some 20 000 professional members. It has also appointed a number of inter-society technical committees studying issues of common interest such as landslides, education, and geophysical data representation. ◆