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) 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

---

**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.
Leeuwpan fine coal dense medium plant

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

Figure 2—Leeuwpan fines plant under construction

Figure 3—Confined spaces for installation
primary cyclone was increased from 120 mm to 145 mm and that of the secondary cyclone from 100 mm to 130 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

<table>
<thead>
<tr>
<th>Circ med RD</th>
<th>Feed ash, %</th>
<th>Product ash, %</th>
<th>Discard ash, %</th>
<th>Yield, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.30</td>
<td>28.7</td>
<td>15.8</td>
<td>68.3</td>
<td>75.4</td>
</tr>
<tr>
<td>1.30</td>
<td>28.4</td>
<td>15.9</td>
<td>68.2</td>
<td>76.2</td>
</tr>
<tr>
<td>1.25</td>
<td>39.0</td>
<td>14.7</td>
<td>63.8</td>
<td>70.8</td>
</tr>
<tr>
<td>1.20</td>
<td>35.6</td>
<td>13.3</td>
<td>63.8</td>
<td>55.8</td>
</tr>
<tr>
<td>1.20</td>
<td>27.5</td>
<td>13.3</td>
<td>62.7</td>
<td>71.1</td>
</tr>
<tr>
<td>1.18</td>
<td>26.5</td>
<td>12.3</td>
<td>50.6</td>
<td>62.8</td>
</tr>
<tr>
<td>1.18</td>
<td>26.2</td>
<td>13.1</td>
<td>52.8</td>
<td>67.2</td>
</tr>
</tbody>
</table>

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

One modification was done to bleed magnetite into the fines plant instead of pumping raw magnetite from 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).

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).
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.

Table V

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed, % ash</td>
<td>36.4</td>
</tr>
<tr>
<td>Product, % ash</td>
<td>26.3</td>
</tr>
<tr>
<td>Discard, % ash</td>
<td>86.8</td>
</tr>
<tr>
<td>Product Yield, %</td>
<td>83.3</td>
</tr>
<tr>
<td>D50 cut-point density</td>
<td>1.998</td>
</tr>
<tr>
<td>EPM</td>
<td>0.0064</td>
</tr>
<tr>
<td>Organic efficiency, %</td>
<td>96.5</td>
</tr>
<tr>
<td>Sinks in float, %</td>
<td>11.05</td>
</tr>
<tr>
<td>Floats in sink, %</td>
<td>0.56</td>
</tr>
<tr>
<td>Total misplaced, %</td>
<td>11.61</td>
</tr>
</tbody>
</table>

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.
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.

Acknowledgement
The authors express their gratitude to Exxaro Ltd. and to Coaltech for permission to publish this paper, and Leeuwpan Management team is gratefully thanked for the opportunity to write and present this project. Witlab staff are thanked for their assistance with the analysis throughout the project.

References
THEUNISSEN, N. Leeuwpan Fines plant, Mining Mirror Magazine, September 2008