Laboratory Evaluation of the Potential for Electrokinetic Belt Filter Press dewatering of Kimberlite Slimes

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ABSTRACT

Reprocessing of diamond mine tailings heaps produces large amounts of fine grained tailings pastes/slurries rich in montmorillonite clays. These materials are generally pumped to their final points of disposal in a tailings dam. It is considered desirable for tailings to be disposed of in a solid state by belt conveyor thus reducing the costs associated with disposal and maintenance and also permitting water recovery. This paper reports the results of laboratory testing which evaluated the potential for electrokinetic belt filter press dewatering of diamond mine tailings. The data show that electrokinetic belt filter press dewatering is viable in principle and at the time of writing, final preparations were being made for full scale trials using an electrokinetic belt filter press.

1 INTRODUCTION

Metallurgical reprocessing of kimberlite old tailings heaps uses water as the processing and transport medium. The process results in two broad types of material, which are differentiated according to their dominant grain size: grits (>75 µm) and slimes (<75 µm). With the increasing importance of sustainable use of water in the mining industry (Welch, 2003) practices such as Paste and Thickened Tailings Disposal (P&TTD) are being adopted increasingly in the diamond mining sector (Vietti, 2004). Water recovery prior to disposal offers a number of advantages including water recovery, reduction in size of disposal facility or increased lifespan for a given facility, (Fourie, 2003; Welch, 2003). Whilst P&TTD processes reduce disposal volumes and recover water, the lack of a dewatering stage means that thickened tailings or pastes must be pumped in a liquid state to the disposal site using high pressure, high volume positive displacement pumps. There thus exists a potential opening for a suitable dewatering technology.

Belt filter presses have been used for dewatering slurries and sludges for several decades since their adaptation from roller presses in paper production. Their use in sewage sludge dewatering has gained widespread acceptance and few changes have been made to the technology in the last decade, (McLoughlin, 2005). Recent full scale trials, which added electrokinetic processes to a standard belt filter press, delivered significant improvements in dewatering performance at low additional power consumption (Lamont-Black et al., 2006). These trials improved the solids content of dewatered sewage sludge from 19% ds to 31 %ds at an additional power consumption of approximately 30 kWhr (110 MJ) per tonne of dry solids.

The rationale of the laboratory work presented here was to investigate the potential for using an electrokinetic belt filter press to dewater thickened tailings to such an extent so as to permit transport by conveyor. Such an achievement would result in a reduction in the capital and operational expenditure associated with pumping and recovery of water additional to that achieved by thickening. Conventional belt press filtration has generally not been used in dewatering kimberlite slimes owing to concerns relating to low permeability of the slimes which are dominated by smectite clays and relatively low throughput rates of conventional belt filter presses.

2 TEST METHODS AND RESULTS

Three types of thickened kimberlite slimes were received from diamond mines in southern Africa. These were evaluated in the laboratory trials, Table 1. The testing schedule was devised to investigate three characteristics of the materials:

- Slump behaviour as the tailings were progressively dried.
- Material indices and properties relevant to electrokinetic dewatering.
- Parameters necessary to design an electrokinetic belt press dewatering system.

Table 1 Characteristics of thickened kimberlite slimes

Sample	Dry Solids Content (%)	Water Content* (%)	Bulk Density (Mg/m^3)	pH
A	57.2	74.8	1.581	9.53
B	37.6	166	1.308	7.88
C	59.6	67.8	1.640	8.63

* Water content defined in the geotechnical sense as (mass water/mass. solids) x 100

2.1 Slump Tests

Static slump tests were performed on the three samples using a standard slump cone. Each sample of slimes was spread out on a large steel tray and regularly turned and mixed to provide gentle air drying; the intention being to characterise the slump behaviour with water content. Figure 1 shows the results for samples A and B. Sample C was difficult to interpret because as drying proceeded it became very sticky such that force was required to remove it from the slump cone resulting in inconsistent results.

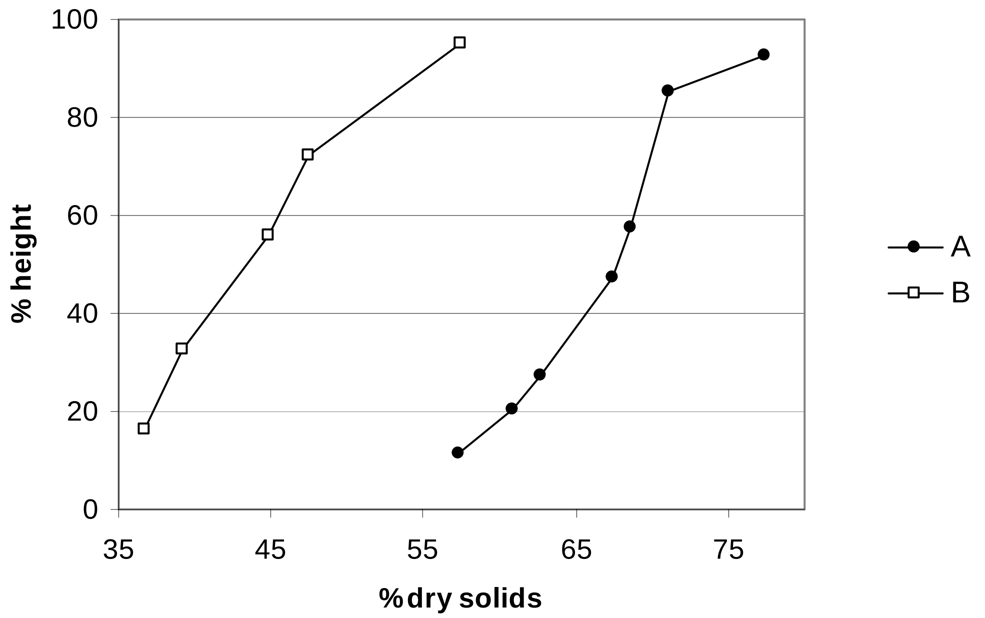

Figure 1 Slump test results for slimes A and B with increasing solids content

These data showed markedly different behaviour between slimes A and B, with the former requiring a much higher solids content in order to achieve a given slump height compared to sample B.

2.2 Material indices Relevant to Electrokinetic Dewatering

The main indices relevant to electrokinetic dewatering are the coefficient of electro-osmotic permeability or (k_e) and the electrical resistivity. The former characterises the flow due to electro-osmosis under a given standard voltage gradient and the latter defines the electrical current that will flow when under a given voltage gradient. From the point of view of designing an electrokinetic belt press dewatering system it is important to characterise these indices independently. However it is acknowledged that they are physically related in that the value of (k_e) is closely related to the zeta potential which is strongly influenced by pH and salinity, both of which influence electrical resistance.

The value of (k_e) was determined using a specially designed electrokinetic testing cell or 'Rosli cell', Figure 2. This equipment provides an irrigated anode (bottom electrode) and open draining cathode (top electrode) and maintains a zero hydraulic head across the sample. Therefore any flow emanating from the cathode is due solely to the electro-osmotic flow induced by the voltage gradient through the sample. The resistivity tests were carried out using the disc electrode method to British Standard 1377 (BSI, 1990). The results of the (k_e) and resistivity tests are shown in Table 2. The values of the electro-osmotic permeability of the diamond slimes fall towards the top of the range of common materials (e.g. Mitchell, 1992) and are thus considered good candidates for electrokinetic dewatering.

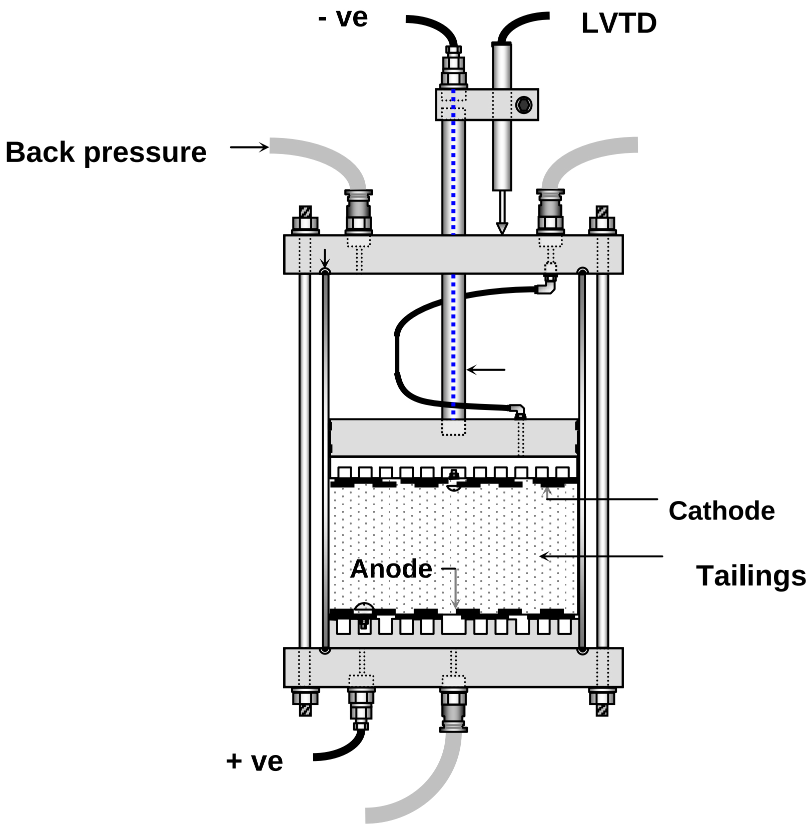

Figure 2 Electrokinetic test cell (Hamir, 1997)

Table 2 Results of electro-osmotic permeability (ke) and resistivity tests

Sample	Coefficient of electro-osmotic permeability (cm^2/sV)	Resistivity (Ωm)
A	7×10^{-5}	3.4
B	2×10^{-5}	3.2
C	8×10^{-5}	9.3

2.3 Electrokinetic Dewatering Tests

The laboratory tests were aimed at simulating the electrokinetic dewatering between a pair of woven electrokinetic geosynthetic (EKG) belts. A critical difference factor in the bench scale simulation is the absence of any shearing action, which is an important characteristic of a working belt filter press and which has been shown to increase dewatering performance over that indicated by static tests.

Standard filter belt material made from woven polyester was adapted to act as electrokinetic filter elements. Slimes from Kimberlite sample A were used for this stage of the testing. The slimes were placed in the electrokinetic cell between an anode and a cathode filter electrodes. The system was placed under a pressure of 70kPa and the resulting filtrate collected over a period of 35 minutes. The variables explored included:

- Sample thickness 10 mm, 20 mm, 35 mm and 50 mm
- Applied voltage 15 V and 30 V
- Spacing of conducting elements in the weave 7.5 mm, 10 mm, 15 mm and 20 mm.

Solids contents were calculated by subtracting the mass of collected filtrate from the original mass of sample and the results were cross checked against changes in the volume of the sample, which were determined by use of an LVDT measurement of the cylinder piston displacement.

An example of the solids content versus time for the 7.5 mm spacing filter electrodes at 15 and 30 V using 35 mm and 50 mm thick samples is shown in Figure 3. The complete data set for the 15 V tests is shown in Figure 4. A percentage dry solid content greater than 65% is required for transportation by conveyor belt.

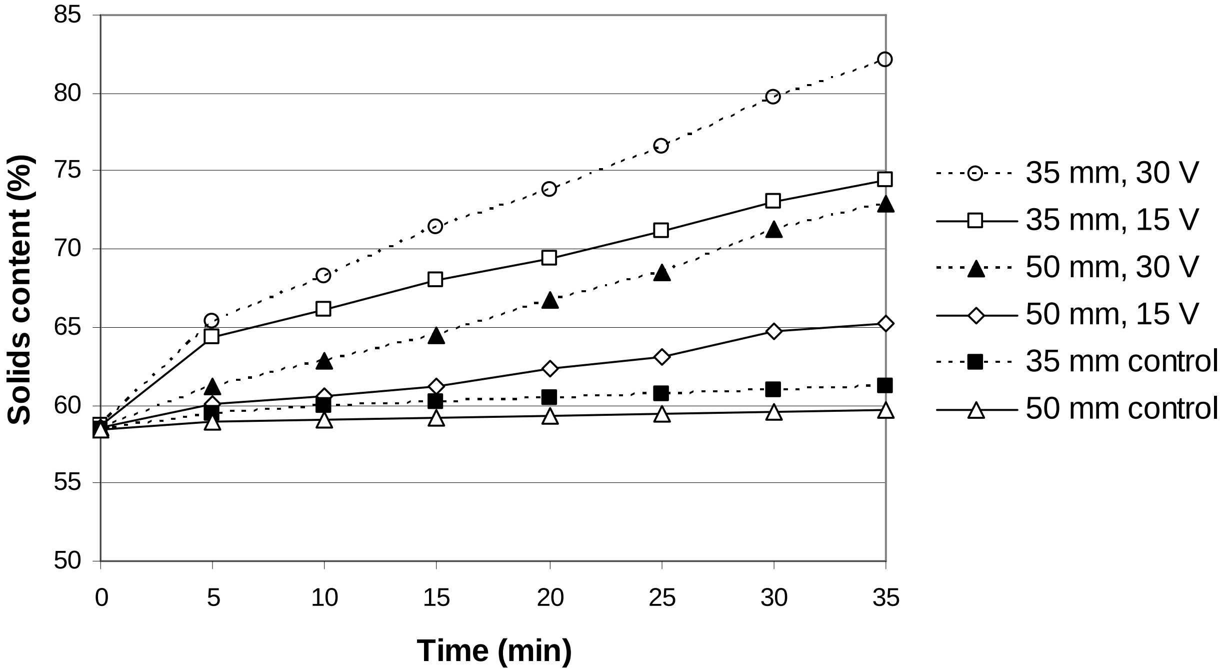

Figure 3 Solids content versus time for 35 and 50 mm samples of kimberlite A slimes dewatered at 15 and 30 V using 7.5 mm filter electrodes

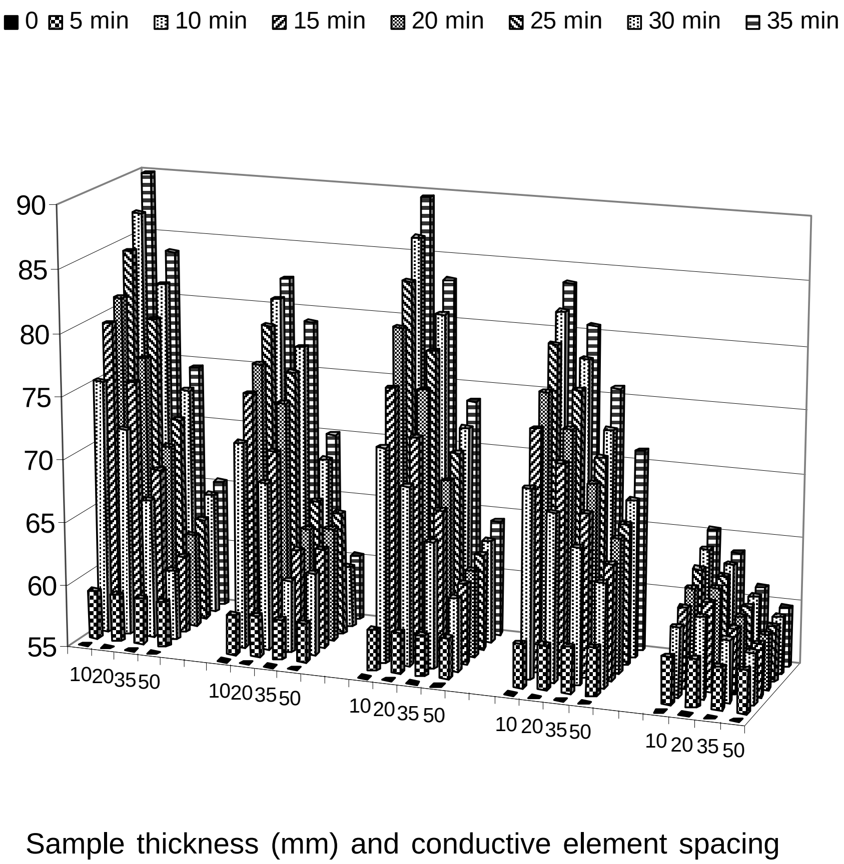

Figure 4 **Dewatering performance of kimberlite slimes from source A at 15 V using all the filter electrodes and control (0V) at 10 mm, 20 mm, 35 mm and 50 mm sample thicknesses**

3 INTERPRETATION

The data from the tests indicate that the dewatering performance was controlled by several factors including:

- Residence time.
- Applied voltage.
- Sample thickness.
- Design of filter electrodes.

The data, as presented on Figure 4 also indicate that for any given target solids content, the parameters can be selected with a variety of different combinations to achieve the required end result. This flexibility means that there can be a balance struck between dewatering throughput, power consumption and cost of belts. Figure 5 presents an example of such an analysis to identify an acceptable range of target solids contents for a working belt press equipped with belts having conductive elements at 7.5 mm spacing. This indicates that, based on these data, the optimum sample thickness for maximum throughput (derived from feed rate and belt speed) lies between 20 and 30 mm.

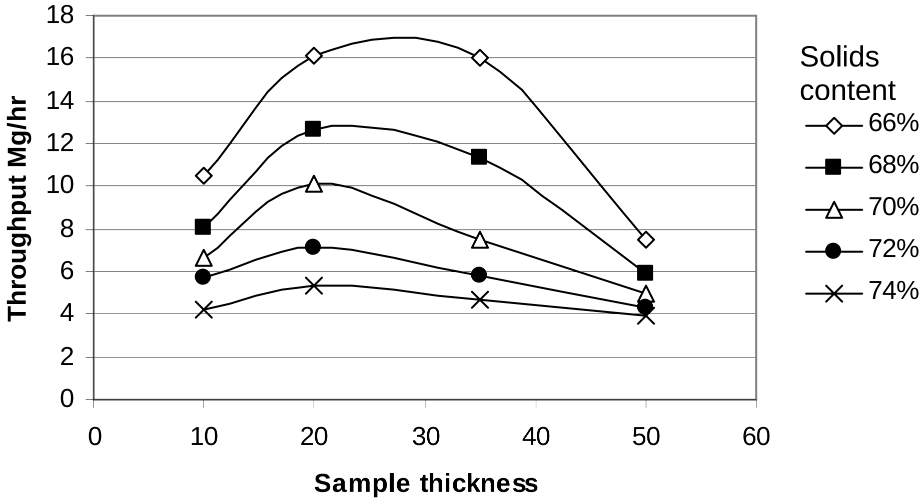

Figure 5 **Optimised throughputs to achieve different target solids contents using 7.5 mm pitch belts**

4 CONCLUSIONS

The objectives of the tests were to characterise the behaviour of diamond mine tailings with decreasing moisture content as an indicator of the ease of transportation by conveyor, to determine the suitability of the materials for electrokinetic dewatering, and characterise the dewatering performance of a simulated belt press configuration using standard electrokinetic test cells. The results of the tests showed that the diamond mine slimes were good candidates for electro-osmotic dewatering and that the percentage of dry solids that could be achieved fell well within the required range for transport by conveyor. Preparations have been finalised for full scale dewatering trials of the material using an electrokinetic belt filter press.

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