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The optimization of an improved method of fine coal dewatering

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Abstract

An improved method of dewatering fine coal (−500 μm) by vacuum filtration was developed and optimized. Tests on a bench scale vacuum filter showed that when a filter cake was deliberately damaged, causing the airflow through the cake to increase and the applied vacuum to decrease, a lower final moisture content could be achieved as well as a higher rate of dewatering.

This method was optimized, taking into account the optimum time to inflict the damage to the filter cake during a single dewatering cycle. The amount and character of the inflicted damage to the filter cake was also investigated. It was found that the optimum time to inflict the damage was as soon as possible after the point of 100% saturation, decreasing the final moisture percentage from 29% to 24%. The configuration of the damage had no significant influence to the final moisture content of the filter cake. This led to believe that the air flow through the cake during dewatering is mainly hindered by a layer of ultra fine coal that will form at the top of a filter cake. Further investigation showed this layer to be approximately a third from the top of the filter cake, relating to a particle size of between 120 and 130 μm.

Keywords: Coal; Dewatering; Filtration

1. Introduction

South Africa is currently listed as the 6th largest coal producer in the world, supplying approximately 285 ton of ROM coal per annum (DME, 2003). Of this, about 14% report as fine coal (smaller than 500 μm) and up to 2–3% can be classified as ultra-fine coal (finer than 100 μm) (Breed, 1992). This amounts to about 30 million tons of fines being produced annually.

Since coal washing is a wet process, this fine fraction is in slurry form, or at best, a very moist solids stream. Coal producers have a few options as to what to do with the fines. Initially, fines and ultra-fines were dumped with the discard streams, but since the value of these fines had been recognised, it was either added to the product streams as is, or alternatively, it was upgraded, dried and sold. The economic potential of coal fines has led to developments in fine coal beneficiation processes, like spirals and froth flotation plants. The main reason for not fully exploiting this energy source is the high levels of moisture associated with the fines fraction of coal. Efficient removal of this moisture will yield definite benefits in finances and handling of the fine coal, while it will also have a positive impact on the environment.

2. Background

Rong (1993) defined the three types of moisture in coal to be surface or free moisture, inherent or capillary moisture and chemically bound moisture. Of these three, only the surface moisture can be removed from the filter cake by mechanical means like filtration and centrifuging. Further studies done on fine coal showed it not to

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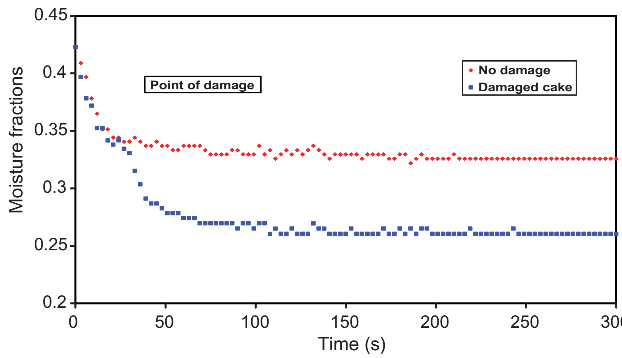

Fig. 1. Results where the filter cake was deliberately damaged as found by Le Roux (2002).

be uncommon for the coal to have a final moisture content of up to 30% after filtration.

A 2001 survey of South African coal beneficiation plants showed that of the then 24 operations, some 18 plants employed processes for fine coal beneficiation (De Korte, 2001). At seven of these plants, the ultra-fine slurries were dewatered using centrifuges or filters. With Tao et al. (2000) showing that a 1% decrease in the final moisture of 3 million tons of clean coal can lead to a saving of US$ 300,000, these amounts of moisture left in the fines are adding up to become a big financial liability.

Le Roux and Campbell (2003) showed that by deliberately damaging a fine coal filter cake, thereby increasing the air flow through the cake at the expense of a lower pressure differential across the cake, will yield a final product with much lower moisture content. It also increased the rate of dewatering and decreased the breakthrough pressure. This phenomenon is shown in Fig. 1.

Fig. 1 clearly shows a rapid increase in the dewatering rate after the filter cake was damaged. The end result yielded a cake that was about 5% drier than for the standard filtration test. To be applicable in industry, this process needs to be optimized with regards to time and method of applying the damage.

3. Experimental setup

Two fine coal samples were obtained from New Vaal Collieries (from the Free State coal field in South Africa), where the thickener underflow stream was sampled. The samples were first dewatered using pressure filters, then air dried for some time, before the remaining moisture was removed in an oven at 60 °C. Table 1 shows the proximate analysis of the coal, while a particle size analysis indicated the coal to be 95%—600 μm and 50%—212 μm. The coal samples were then repulped to make up the feed to the desaturation experiments.

The experiments were done on a bench scale filter. Operating conditions were chosen to emulate the belt filters currently in use at New Vaal Collieries, taking into account the type of coal, filter cake thickness and retention time on the filter, and also using the same filter cloth (Devtex 356). An applied vacuum difference of 45 kPa was used.

Table 1
Proximate analysis of the different coal samples from New Vaal

	Sample 1	Sample 2
% Moisture (SABS 924)	4.74%	5.04%
% Ash (ISO 1171)	52.60%	43.99%
% Volatile matter (ISO 562)	16.78%	18.53%
% Fixed carbon	25.88%	32.44%
Calorific value	11.20 MJ/kg	14.75 MJ/kg

The filter system consisted of a glass bell jar that could be evacuated with a filter head fitted onto the top of the bell. A glass beaker, situated inside the bell jar on a load cell was used to collect the filtrate, and to measure the filtrate mass continuously. Data logging (time, applied vacuum, and filtrate mass) was done by a computer (Fig. 2).

The first sample was used to determine the optimum time during the dewatering cycle to damage the filter cake, as well as to establish the ideal configuration of the damage.This was done under an applied vacuum of 45 kPa. The retention time for each test was 300 s after the point of 100% saturation was reached. The cake thickness was 15 mm, relating to 60 g of dry coal per experiment. After each test the moisture in the cake was determined using the SABS 924 standard.

A test was done without damaging the cake. This served as a control for later comparisons. In all the subsequent tests the filter cake was damaged at different times during the dewatering cycle, punching apertures into the cake using an array of implements.

The second sample was used to determine if there was a certain depth that a filter cake has to be damaged to obtain optimum airflow through the cake. The tests were carried out at the same conditions as for the first sample, but the damage that was inflicted onto the cakes differed in depth.

4. Results and discussion

Selected results from the above tests are shown in Figs. 3–5. Fig. 3 shows a summary of results for the tests done where the damage was inflicted at different times during the dewatering cycle. It can be seen that the optimum final cake moisture occurred when damage occurred the point of 100% saturation, i.e. where all inter- and intra-particle voids are totally filled with water, without any excess water on top of the filter cake. It yielded a final moisture percentage of 25% compared to 29% final moisture for the standard filtration test. Each of the tests was repeated three times which gave