CENTRIFUGAL DEWATERING OF FILTER CAKE

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Abstract

The dewatering of filter cake in a redundant Broadbent batch centrifuge was investigated. With some minor modifications, the machine reduced the mass of the incoming cake feed by about 30 percent. At the same time approximately half the pol in the filter cake feed was recovered in the centrate return. The potential gains which could be realised from the mass reduction and pol recovery provide a considerable economic incentive for further consideration of filter cake dewatering on a full scale.

Introduction

During the past decade the application of centrifuges, particularly of the solid bowl decanter type, to the problem of sludge dewatering has become increasingly widespread[1]. The potential use of such machines in the raw sugar industry for the separation of primary muds from clarifier underflows has evoked considerable interest, especially in Australia.[2,3,4] Centrifugal mud treatment as an alternative to conventional rotary vacuum filtration offers the exciting possibilities of obtaining improved retention, lower pol losses and cake moistures, whilst at the same time obviating the addition of bagacillo.

However, the results obtained to date have been disappointing, being characterised by low retentions which have necessitated the use of bagacillo, lime and flocculants.[2,3] It was concluded by one author that a centrifuge cannot match the performance of a well operated filter installation.[2] On the other hand, these tests have shown that centrifugation can produce improved pol recoveries and lower cake moisture contents.

From the foregoing results it appeared that it might be a viable proposition to apply centrifugal treatment to the filter cake produced by a rotary vacuum filter in order to achieve additional dewatering and hence a reduction in final cake mass and pol losses. During 1973 Amatikulu converted to a continuous C station which left a number of batch machines redundant. Although these machines were not necessarily ideally suited for the purpose, they were available and hence it was decided to conduct a series of tests at Amatikulu during the 1974/75 season, to assess the centrifugal dewatering of filter cake. This paper presents the results of this investigation.

Experimental procedure

One of the available machines, a semi-automatic Broadbent (48 × 30) batch C centrifugal, was set up adjacent to the main filter cake discharge conveyor from the filter station at Amatikulu. A schematic diagram of the experimental layout is shown in Figure 1.

Filter cake was sampled from the feed and discharge belts by preparing a composite of a large number of small catch samples. These were analysed in each case for moisture % and pol % filter cake. Centrate from each test was collected in the centrate vessel where the quantity was measured and samples were taken for analysis of pol % and brix % centrate. The quantity of filter cake charged to the batch machine was calculated by an inductive method based upon the measurement of moisture % feed and discharge and of centrate quantity as shown in Appendix 1.

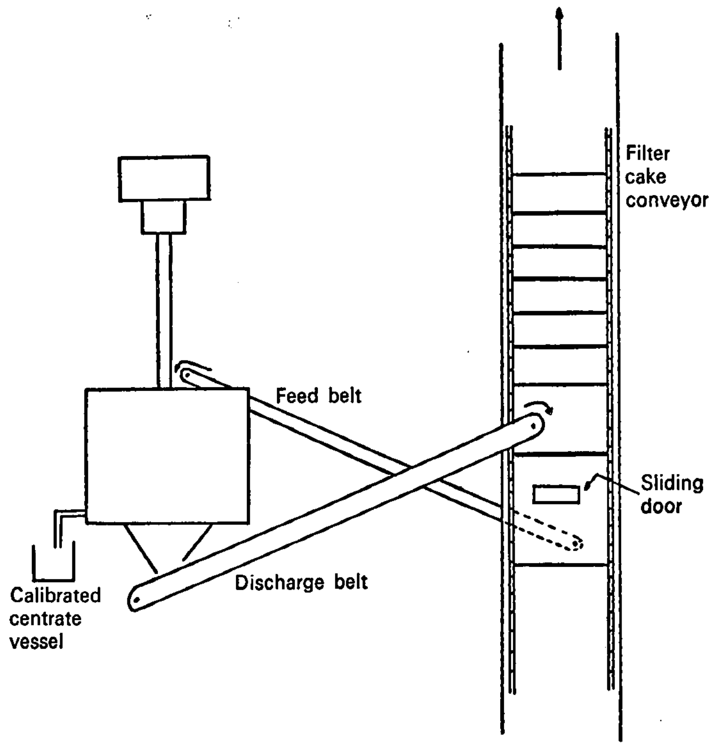

FIGURE 1 Schematic layout of test equipment.

Tests were conducted to assess the effect of rotational speed, spin time, charge mass and charge moisture content on the quantity and quality of centrate produced.

Results and discussion

Mechanical considerations

It was observed that the original plough tip permitted a thin layer of material to remain on the screen which resulted in severe blinding and a rapid deterioration in machine performance. The problem was overcome by installing a new and slightly modified plough tip.

Initially considerable difficulty was experienced with screen blinding. This was found to be attributable to a progressive build-up on the fine backing screen. The problem was solved by completely removing this screen. Thereafter tests were conducted using either a typical A massecuite slotted copper screen or a conventional C massecuite round holed screen, both of which gave similar results. The latter type of screen was used for most of the tests. No significant deterioration in performance was detected resulting from screen blinding, though as a precautionary measure, the basket was periodically washed down with a hot water jet while running at charging speed.

Effect of spin time

A number of tests were performed with the machine running at 1 000 rpm. The quantity of centrate removed was measured at one minute intervals over a total spin time of nine minutes. The average cumulative percent mass reduction and rate of centrate removal as a function of time are shown in Figures 2 and 3 respectively.

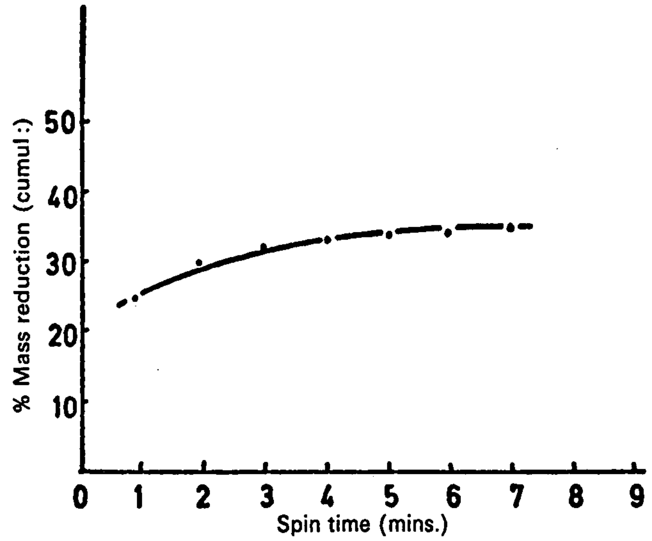

FIGURE 2 Cumulative mass reduction

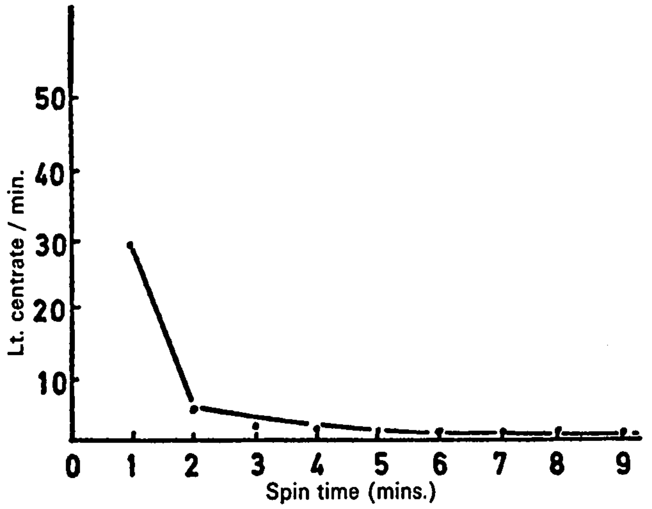

FIGURE 3 Centrate extraction rate.

These results indicate that the bulk of the centrate was removed very rapidly from the filter cake and that essentially constant weight was attained after 5 minutes at a speed of 1 000 rpm. The achievement of a mass reduction of around 30 percent with a final cake moisture content between 65 and 70 percent was most encouraging at that stage.

Effect of rotational speed

Two series of tests were run at 1 000 and 1 500 rpm respectively, using a constant spin time of 9 minutes in each case. The results of these tests are summarised in Table 1.

TABLE 1
Effect of rotational speed

	Rotational Speed	
	1 000 rpm	1 500 rpm
Moisture % cake feed	76,3	76,5
Moisture % cake discharge	64,9	65,3
Centrate produced (litres)	32,4	36,4
Calculated charge mass (kg)	98,9	112,9
% Mass reduction	32,8	32,2
Pol % cake feed	1,10	1,08
Pol % cake discharge	0,87	0,78
Pol % centrate	1,87	1,86
Brix % centrate	2,66	2,61
Centrate purity	70,3	71,3
% Pol recovery		
based on feed / discharge	46,8	51,1
based on feed / centrate	55,7	55,5

Although it is likely that the initial rate of centrate production was more rapid at 1 500 rpm. the higher speed of rotation did not produce any significant increase in the degree of dewatering achieved. In addition, it was found that extreme care was required when charging the machine for the higher speed runs in order to ensure an even distribution of material around the basket to maintain balance and prevent excessive vibration. As a result it was decided to standardise on 1 000 rpm for all further tests.

Effect of feed rate and moisture content

Many runs were done at 1 000 rpm for 9 minutes to determine the effect of charge mass and moisture level on the degree of dewatering obtained. During these tests, the charge mass varied over the range 50-250 kg and feed moisture content from 72 to 85 percent. The results of these tests are depicted graphically in Figures 4 and 5.

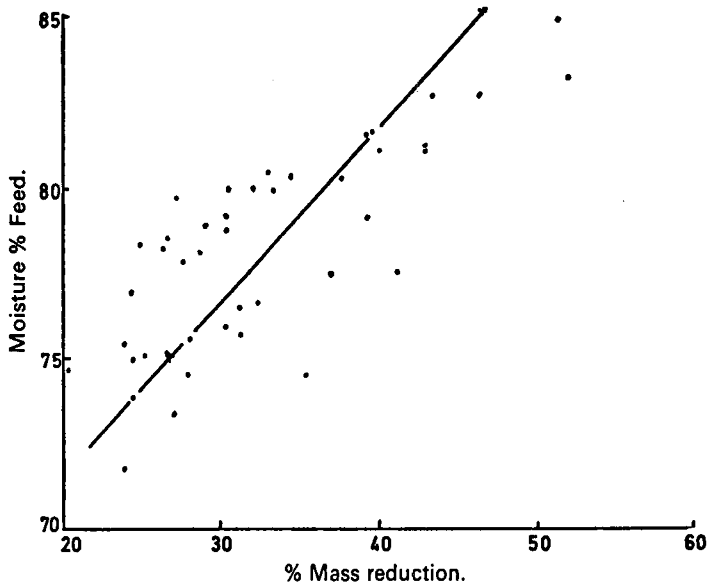

FIGURE 4 Correlation between mass reduction and feed moisture content.

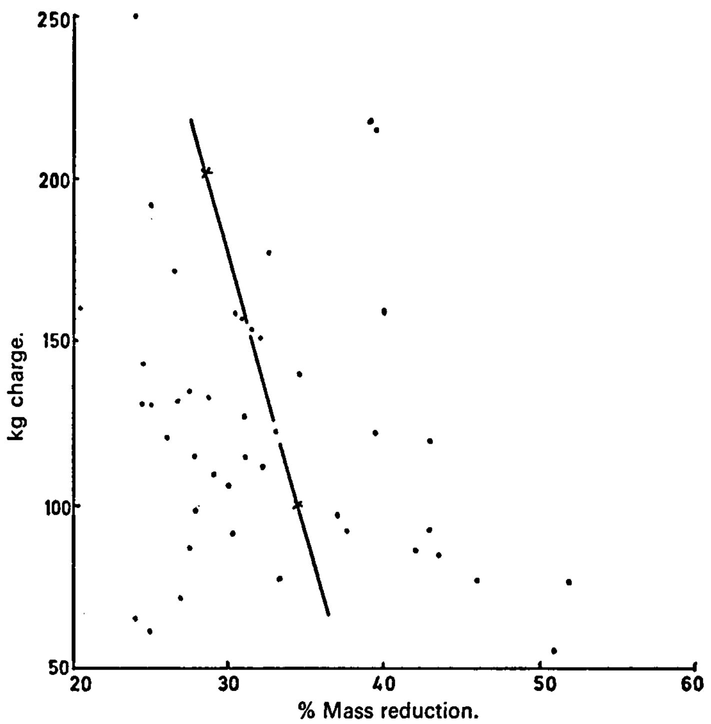

FIGURE 5 Correlation between feed rate and mass reduction.

As might be expected, there was a strong correlation between the % mass reduction of the cake and the moisture % feed. No attempt was made at any stage to adjust, by artificial means, the moisture content of the feed to the centrifuge. It is interesting to note the fairly wide variations in incoming moisture levels which are probably attributable to changes in both filter performance and cake permeability. In general, high-moisture contents are consistent with higher pol losses, unless cake washing is extremely efficient. However in each case the centrifuge reduced the moisture content of the filter cake to between 65 and 72 percent.

Statistically there is also a significant correlation between the mass charged to the centrifuge and the % mass reduction as shown in Figure 5, although there is a fairly wide scatter of points around the line.

The observed trend indicates that the degree of dewatering diminished as the load to the machine was increased.

Centrate quality and pol recovery

Average centrate clarity was similar to that obtained for the filtrate return from the rotary vacuum filters. The suspended solids content was usually between 1 and 2 percent by weight. A few runs were done where filtrate was sampled at one minute intervals and analysed for pol and brix. One such set of results is illustrated in Figure 6, although it should be noted that the absolute levels of pol and brix shown are abnormally high.

It is interesting to note that both pol and brix % centrate show a sharp increase over the first two minutes of spin time. This is presumably due to the fact that the bulk of the centrate, which is readily removed during the early stages, is extracted from the larger and more accessible interstices in the cake mass. These are the micro pathways which are more easily penetrated by wash water on the filters and the resulting dilution effect would cause the lower pol and brix figures shown. Under extended centrifugation the less diluted residual juice from the more "inaccessible" portions of the cake is extracted, leading to a rise in both the pol and brix figures. This reasoning however does not account for the observed purity rise with spin time which is as yet unexplained.

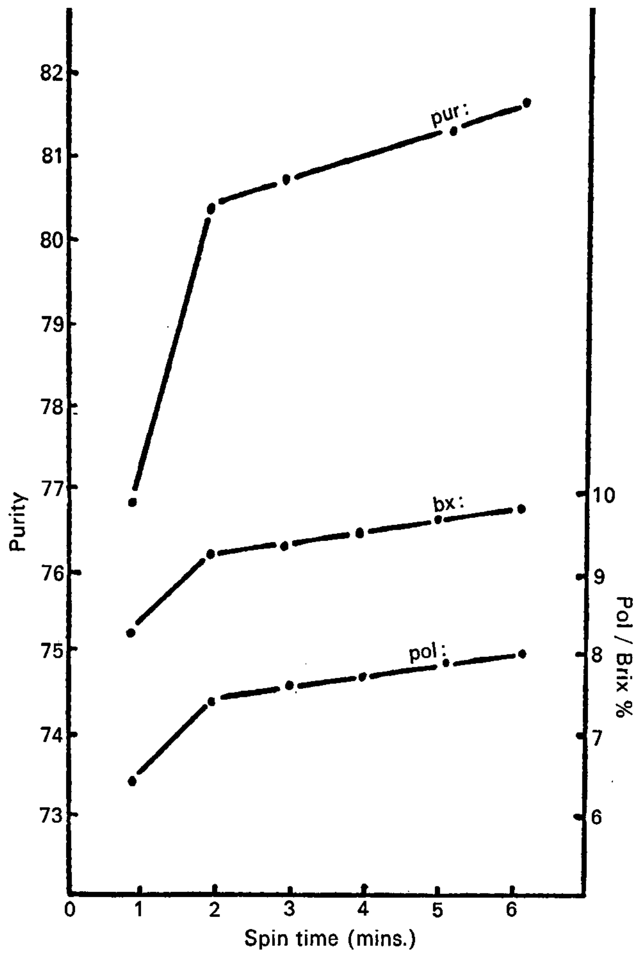

FIGURE 6 Variation in centrate quality with spin time.

A typical set of detailed analyses is given in Table 1 which reflects the weighted average results from a series of fourteen independent runs at 1 000 rpm. Centrate purity varies fairly widely in the range 63 to 81, the average value being just over 70. However, it was found that there was a strong correlation between brix % centrate and pol % filter cake in the feed.

This confirms similar observations made by Hale, Meredith and Whayman in their pilot studies on cane mud filtration.[5] Their work also records some anomalies in the purity of residual juice in cake, which tended to increase with increasing pol % cake.

The figures in Table 1 also reflect the difficulty in obtaining accurate pol balances across the centrifuge in these tests. This is evident from the different results obtained for the percent pol recovery depending upon the method of calculation. However, it appears realistic to assume that actual pol recoveries in the region of 50 percent were achieved.

Conclusions

The results of the present study indicate that it is possible to achieve a mass reduction of about 30 percent and pol recoveries in the region of 50 percent by dewatering filter cake in a conventional batch centrifuge. To place these findings into perspective, it becomes necessary to extrapolate them to a full scale operation. For a mill with a crushing rate of 200 tch the following typical conditions are assumed to apply.

Filter cake % cane	5,0
Pol % filter cake	1,0
Pol % cane	13,0
Capacity of dewatering centrifuge	200 kg/spin
Spin duration (total)	6 minutes

Based on the above figures a total of 5 machines would be required to handle the total filter cake output of 10 tons/hour. The projected mass reduction of 30 percent would have a considerable impact on the final cake output weight, whilst the centrate return of 3 tons/hour should have a negligible effect on clarifier or evaporator capacity.

The pol recovered % pol in cane would amount to 0,19 which in this case is equivalent to approximately 35 kg/hr of additional sucrose in the bag, after correcting for the SJM recovery (centrate purity 70, molasses purity 40).

This quantity of potential pol recovery should provide a considerable economic incentive for giving serious consideration to the centrifugal dewatering of filter cake.

Acknowledgements

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REFERENCES

1. Zurcher, H. E. (1974). The application of centrifuges to the dewatering of sludges. Filtration and Separation, Nov./Dec. 1974, 606-612.
2. Stewart, P. N., Noble, A. G., Brotherton, G. A. and Nix, K. J. (1974). Evaluation of a solid bowl centrifuge for mud treatment. Proc. QSSCT **41**, 249-259.
3. Hale, D. J., Meng, K. J., Meredith, T. W. and Whayman, E. (1974). Mud centrifugation — Preliminary trials. Proc. QSSCT **41**, 243-248.
4. Hunwick, R. J. (1974). An engineer's guide to the MercoBowl centrifuge, Proc. QSSCT **41**, 261-267.
5. Hale, D. J., Meredith, T. W. and Whayman, E. (1974). Pilot studies on cane mud filtration. Proc. QSSCT **41**, 269-278.

Appendix 1

Calculation of charge mass to centrifuge

The quantity of filter cake charged to the machine was calculated from the measured quantity of centrate together with the cake feed and discharge moisture contents. It is assumed that:

Moisture % filter cake feed = f
Moisture % filter cake discharge = d
Mass of centrate collected = C
Mass of filter cake feed = F
Mass of filter cake discharge = D

By mass balance

$$F = D + C \quad \ldots\ldots\ldots \quad (1)$$

By moisture balance

$$\frac{F.f}{100} = \frac{D.d}{100} + C \quad \ldots\ldots\ldots \quad (2)$$

or $F.f = D.d + 100C$

Now substituting for D from equation (1) yields

$$F.f = (F - C)d + 100C$$

By re-arrangement this becomes

$$F(f - d) = C(100 - d)$$

And hence the calculated charge mass, F, is given by

$$F = \frac{C(100 - d)}{f - d}$$

i.e. charge mass =

$$\frac{\text{Centrate mass (100 — Moisture \% discharge)}}{\text{Moisture \% feed — Moisture \% discharge}}$$

The accuracy of this inductive method was verified by loading the machine with a known quantity of filter cake and then calculating the charge mass according to the formula. The results of these tests are shown in Table 2.

TABLE 2

Moisture % feed	Moisture % discharge	Centrate Mass (C)	Charge Mass Actual	Charge Mass (F) Calculated
79,9	70,5	15,7 kg	50 kg	49,3 kg
79,2	70,0	15,7 kg	50 kg	51,2 kg
77,6	70,9	11,7 kg	50 kg	50,8 kg