THE APPLICATION OF A HORIZONTAL VACUUM BELT FILTER TO SMUTS DEWATERING AND CANE MUD FILTRATION

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Abstract

A pilot scale horizontal vacuum belt filter was used to dewater smuts mud and to filter cane mud. The filter gave good results on smuts dewatering, offering several advantages over the existing system, including the fact that no flocculant is required. Large scale units of this type are to be used at the Maidstone and Felixton II mills for smuts dewatering. The performance on cane mud filtration was encouraging. Filtercake of the same or better quality as produced by the rotary drum filters could be obtained.

General Description

The horizontal vacuum belt filter (HBF) consists of two endless belts, one running inside the other. The inner belt, called the transporter belt, is a heavy rubber belt with raised ribs across its width. Raised curbs contain the slurry. The outer belt, made of a suitable type of filter cloth, rests on the transporter belt on its horizontal run. The spaces between the filter cloth and the transporter belt, created by the ribbing, form vacuum chambers. These chambers are evacuated through small holes in the centre of the transporter belt. A vacuum manifold or box runs along under the transporter belt in the vacuum region. The seal between the manifold and the belt is created by contact between HDPE seal strips on the manifold and a sacrificial wear belt under the transporter belt. The seal is assisted by the injection of water. The transporter belt is supported by a low pressure cushion of air which reduces belt drag to a minimum.

The feed is run onto the belt just before the start of the vacuum region. Filtrate is removed through the vacuum manifold to a receiver from where it is pumped away. The cake is discharged at the point where the filter cloth turns on the end roller. Water sprays, just after the cake discharge point, help to prevent blinding of the cloth. This water does not mix with the filtrate. The belt filter is driven by a variable speed drive unit connected to a roller which drives the transporter belt at the discharge end of the unit.

The filter used in the test work included a number of improved features not present in older HBF designs.[1] These include:

(1) the vacuum seal system (described above), which allows for operation at higher vacuums and belt speeds than previously possible;

(2) automatic tracking by a steering roller. Since no pinch roller or similar mechanism is used, cloth life is increased. A bowed roller removes creases from the cloth belt.

The operation of the HBF on an application such as cane mud filtration can be divided into 3 distinct zones.

These are:
- feed zone
- wash zone
- drying zone

The three zones can be distinguished as shown in Figure 2. The feed zone runs from the start of the vacuum region to the adjustable retaining dam which is made of a weighted rubber flap. The wash zone runs from the retaining dam to the point where no free water is visible on the cake. The drying zone runs from the end of the wash zone to the end of the vacuum box. The wash water addition point is adjustable.

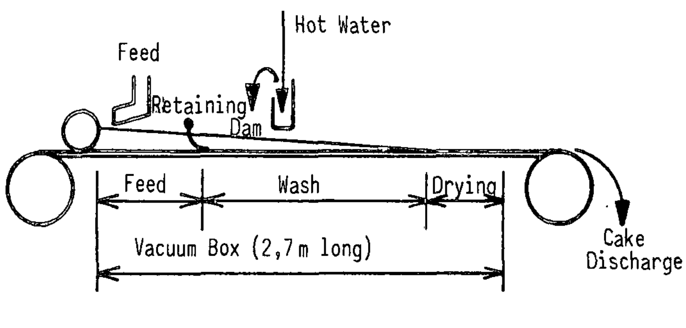

FIGURE 2 The three zones of filtration

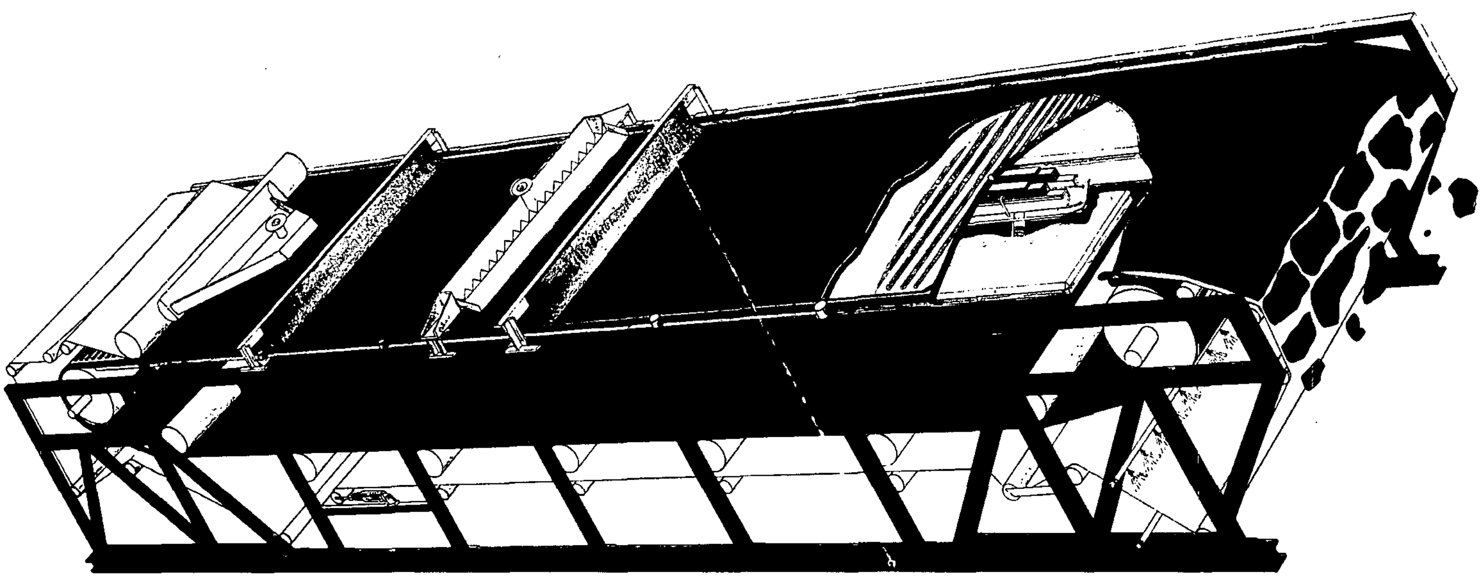

FIGURE 1 The horizontal vacuum belt filter

These zones are not relevant to an application such as the dewatering of smuts, since no washing of the cake is required, and it is not necessary to use a retaining dam to control the feed.

Application to Smuts Dewatering

Introduction

The problem of dewatering smuts from a wet-type flue gas scrubber system has been approached in a number of ways.[2,3,4,5,6,7] At Maidstone Mill the final dewatering of smuts has been carried out using a multi-roller filter (MRF).[8] Two problems arise with this system:

- there is no standby plant for the MRF
- the MRF requires the use of a flocculant to work effectively, which results in high running costs.

As a result of these problems, various alternatives/standbys to the MRF have been considered.

One of the possible alternatives to the MRF is a vacuum belt filter. This type of filter has been applied successfully in Australia on smuts dewatering.[6,7] Problems encountered with the cloth life and tracking, however, led to the Australian workers recommending the use of rotary drum filters. The rotary drum filter has disadvantages in this application as it is expensive[4] and inefficient use is made of the available filter area. When the pilot HBF (1m² filtration area) became available, it was decided to carry out tests on smuts dewatering using this unit.

Scope of the tests

As a result of the off-take of bagasse for the manufacture of animal feeds, it is often necessary to feed the Maidstone boilers on a mixture of bagasse and coal. This causes a significant change in the properties of the smuts. Because of this situation, tests had to be carried out with the boilers burning a mixture of coal and bagasse and with the boilers burning bagasse only.

Tests were also carried out to investigate the effects of different belt speeds and the effects of the flocculant used on the MRF.

Methods

The HBF was installed in the smuts removal system in parallel with the MRF, as shown in Figure 3.

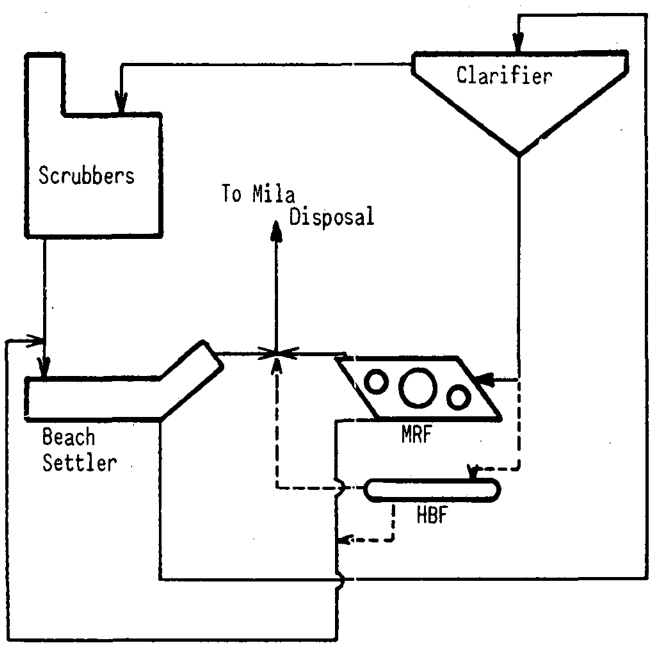

FIGURE 3 Installation of the HBF for smuts dewatering

The performance of the filter was evaluated by sampling the cake and analysing for total solids content. Feed and filtrate samples were also analysed for total solids. Dissolved and suspended solids were measured in the filtrate for some tests. All solids figures are reported on a m/m basis.

The throughput of the filter was measured by weighing the quantity of cake produced within a given time. In the case of the tests carried out with the boilers burning bagasse only, the throughput was calculated from a mass balance using the filtrate flow-rate (which was measured by the time taken to fill a tank). The quantity of sealing water was measured and taken into account.

Results

Boiler Fuel: Coal and Bagasse mixture: the results of the tests carried out with the boilers burning a mixture of fuels are given in Figure 4. The filter was run at an average vacuum of -75 kPa with the belt speed set at the maximum of 12 secs/m. The average total solids content of the filtrate from these tests was 1,3% while the average suspended solids content was 0,03%. The average total solids content of the feed to the HBF was 7,1%.

Boiler fuel: Bagasse only: the results of the tests run with the boilers burning bagasse only are given in Figure 5. The filter was run at an average vacuum of -78 kPa and the belt speed was again set at the maximum (12 s/m). The average suspended solids content of the filtrate was 0,04% while the total solids content averaged 0,14%. The total solids content of the feed averaged 8,3%.

Varying belt speed: three tests in which the belt speed was varied were carried out at a constant throughput of 425 kg dry solids/h/m². The results of these tests are given in Figure 6. The filter was run at a vacuum of -75 kPa. The total solids content of the filtrate averaged 0,12% while the suspended solids averaged 0,02%. The average solids content of the feed was 8,3%. The boilers were burning bagasse only during these tests.

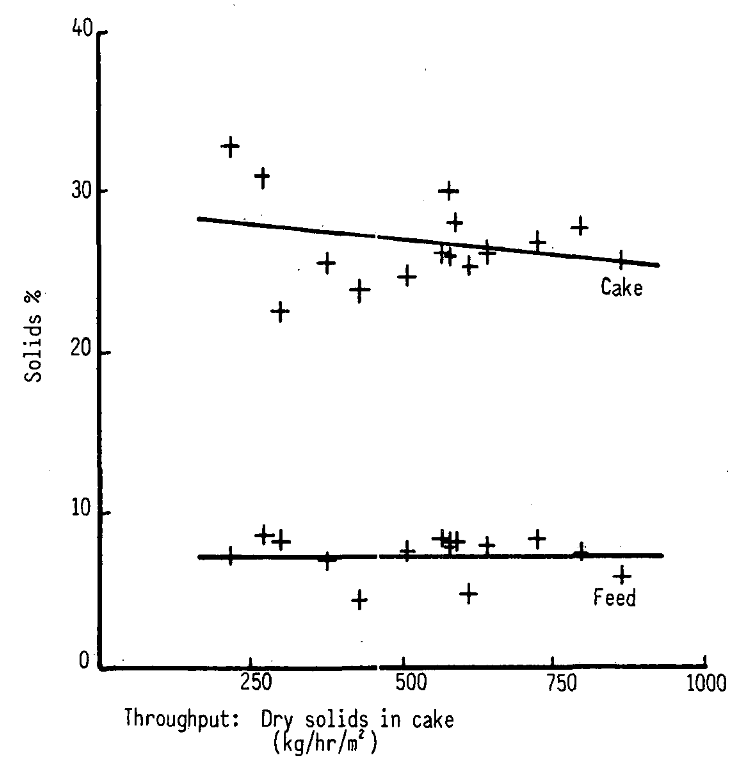

FIGURE 4 HBF performance with boilers burning bagasse and coal

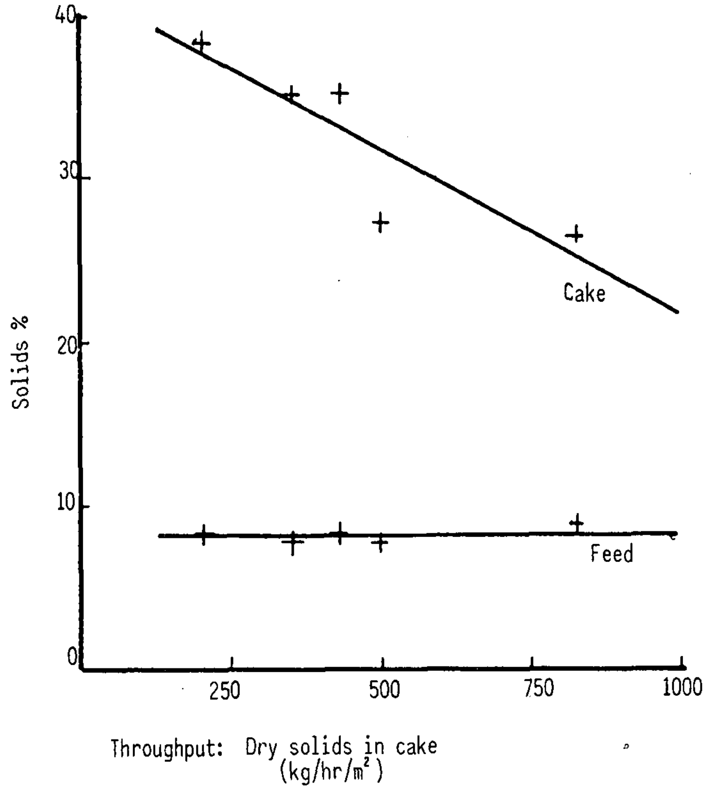

FIGURE 5 HBF performance with boilers burning bagasse only

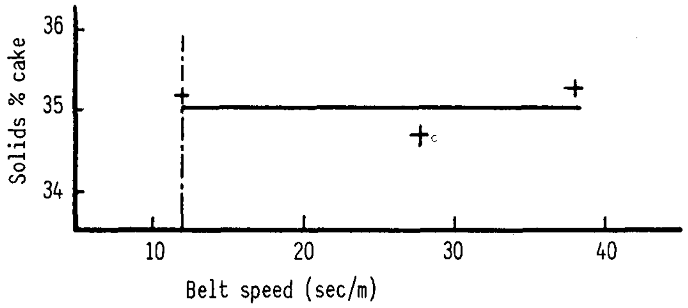

FIGURE 6 The HBF's performance at varying belt speeds

Discussion

Filter Performance and Throughput: the main considerations in assessing the performance of the HBF as a smuts dewatering unit are the:

(1) degree of dewatering of the smuts that can be achieved;

(2) clarity of the filtrate;

(3) throughput of the unit.

Experience with the MRF and the HBF shows that a cake of 25% solids is quite adequate while 30% solids gives an excellent crumbly cake. This is true for smuts derived from bagasse only and for smuts derived from a mixture of coal and bagasse. From Figure 4 it can be seen that a cake of greater than 25% solids can be produced up to a throughput of about 800 kg/h/m², when the boilers are burning a mixed fuel. When the boilers are burning bagasse only, a cake of 25% solids is produced at a throughput of approximately 800 kg/h/m² (Figure 5) with cake of greater than 30% solids being produced at throughputs of less than 600 kg/h/m². The filtrate quality obtained from the HBF depends on the type of cloth used. In the tests a polyester mono-filament cloth with a permeability of 60 cfm was used. (Permeability of 1 098 m³ dry air/h/m² at 12,5 mm W.G.) This cloth gave a filtrate which was much clearer visually than that produced by the MRF. Unfortunately comparative figures are not available.

Variations in belt speed: from Figure 6 it can be seen that varying the belt speed has little effect on the filter's performance. This suggests that in the range of speeds tested the cake is so porous that the thickness of the cake has little influence on the rate of dewatering. Variable speed however, remains an important feature of the HBF as:

(1) at high feed rates the feed tends to overflow the curbs of the belt at the back. To overcome this the belt must be speeded up. (Multiple feed points could also be used);

(2) at low feed rates the feed does not cover the belt. The belt speed must be dropped in this case.

Feed conditioning with flocculant: two tests were run with the flocculant used to condition the feed to the MRF. The solids % cake improved by about 3%. The filter performs quite adequately however, without the use of the folucculant and it was felt that no further work in this direction was necessary.

Blinding of the filter cloth: it was found that a significant drop in throughput occurred if the water sprays were not working efficiently. This occurred when the nozzles choked up or the water pressure dropped. It is thus important that a controlled pressure is used for the cloth cleaning water sprays.

Cost comparison with the MRF (belt replacement): a major consideration in selecting a HBF as an alternative/standby to the MRF is the cost of belt replacements, which forms a major part of the maintenance costs on these units. A comparison of costs is given in Table 1. This indicates an average annual belt replacement cost for the HBF of between 10 and 15% of that for the MRF.

TABLE 1

Costs for belt replacements on the HBF and MRF

UNIT	BELT	LIFE (YEARS)	REPLACEMENT COST	APPROX. AVER. COST P.A.
6m² Belt Filter	Filter Cloth	0,75 - 1	R700	R800
	Transport Belt (rubber)	10	R12 000	R1 200
	Sacrificial Wear Belt	½ - 1	R100	R130
MRF	Filter Belt (X2) (Stainless Steel)	1	R16 000	R16 000

Conclusion

From the test work carried out with the pilot belt filter it is obvious that the HBF is a viable alternative to the MRF. It has a number of advantages:

(1) no flocculant is required (a saving of R16 000/season);

(2) belt replacement costs are lower (a saving of about R14 000/season);

(3) the HBF is mechanically simpler than the MRF which should lead to lower maintenance costs and possibly higher reliability.

Application to Cane Mud Filtration

Introduction

The use of a horizontal vacuum belt filter for cane mud filtration was suggested by Hale[9] in 1971. Crees, Hutchinson and Willersdorf[10] carried out preliminary investigations into the use of an HBF for mud filtration in 1982. This was followed by further work by Crees and Willersdorf[11] in 1983. They concluded that although the HBF had potential, it would be better to turn attention to optimizing the rotary drum filters already in operation. However, since local conditions differ from those in Australia, where the work mentioned above was carried out, and the HBF test unit incorporated new features, it was decided to test the HBF on cane mud filtration.

Method

Installation of the HBF: the HBF was installed in parallel with the 70 m^2 Dorr-Oliver rotary drum filter at Maidstone, as shown in Figure 7. The HBF was fed the same mud/bagacillo mixture as the drum filter, with the feed being bled off a recirculating line to maintain the feed temperature. The cake was discharged on to the mud belt which removes mud from the drum filter.

HBF operating conditions: the feed, wash water and belt cleaning spray water were maintained at ± 85°C. The filter was run at a vacuum of between −75 and −80 kPa. Due to the nature of the cake, filtration was slow and the filter was run at its slowest speed of 270 seconds per cycle. This means that any point on the belt takes 270 seconds to pass along the vacuum region.

Test runs: seven test runs were carried out. During the first five the zone lengths were varied to establish the conditions which would give the best performance. During the last two test runs the filter was run for 24 hours each without changing conditions to assess the extent of blinding of the filter cloth.

Filtrate was sampled at regular intervals during the test runs and analysed for purity, brix and suspended solids. The flowrate was measured by the time taken to fill a tank.

Results and Discussion

Filter Feed: the filter feed is run into the feed zone as shown in Figure 2. The thickness of the cake depends on the cycle time of the cake formation or feed zone. The thickness of the cake is important as it is directly related to throughput and has an effect on the washing efficiency.

It was found that a cake thinner than 5 mm resulted in problems with cake discharging. It was found that a cake 6 mm thick, corresponding to a 30 s feed zone, gave the best performance in terms of pol lost in filter cake. The throughput with a 6 mm cake was 19 kg dry solids/m^2/h. The relationship between cake thickness and cake formation time is shown in Figure 8. The relationship between throughput and cake thickness is given in Figure 9.

It should be noted that a cake thickness of 5 mm or less could be run if a doctor knife or air discharge system were used. This should result in an improvement in performance of pol % cake but at the expense of throughput.

Cake Washing: as a result of the design of the HBF there is no facility for excess wash water to run off the cake. This means that all wash water applied to the cake surface must pass through the cake. The quantity of wash water that can be added is therefore limited by three factors:

(1) the resistance of the cake;

(2) the requirement that the filtrate does not become too dilute (generally aim for about 6, 5–7% brix in filtrate);

(3) the length of the wash zone, which is restricted by the length of the drying zone required to give the desired cake consistency.

It was found that a wash cycle time of 200 s could be used with a feed zone of 30 s which resulted (over the final 24 hour run) in an average pol % filter cake of 0,5 with a filtrate brix of 6,6 (cake thickness of 6 mm). If a higher throughput is required, a longer feed cycle time must be used, which will reduce the available wash zone and thus lead to an increase in the pol in the cake.

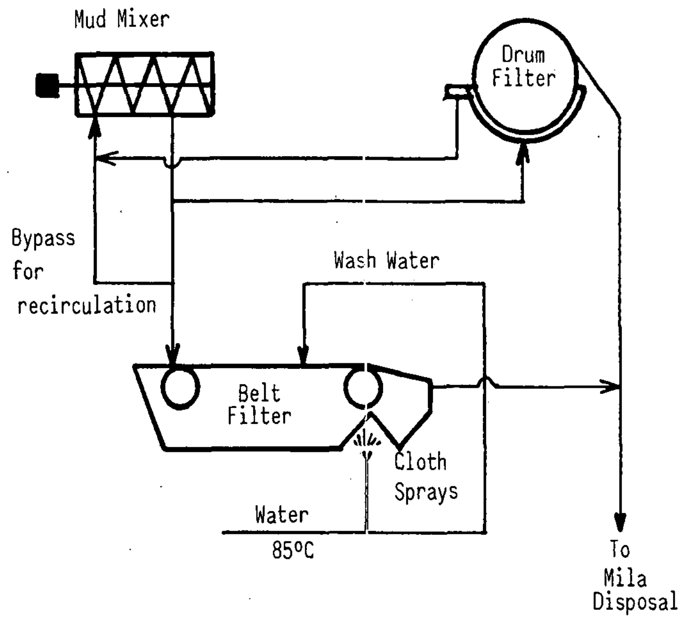

FIGURE 7 Installation of the HBF for cane mud filtration

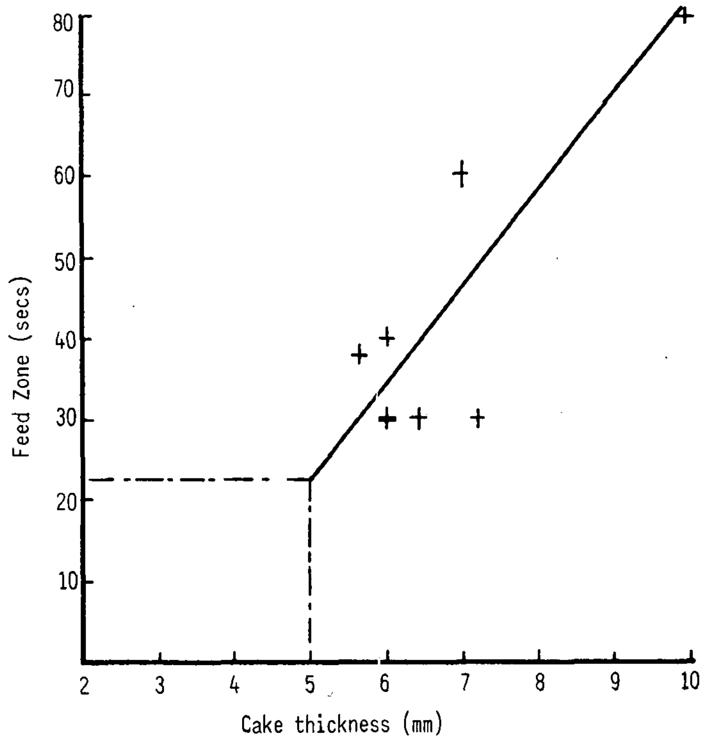

FIGURE 8 The relationship between feed cycle time and cake thickness

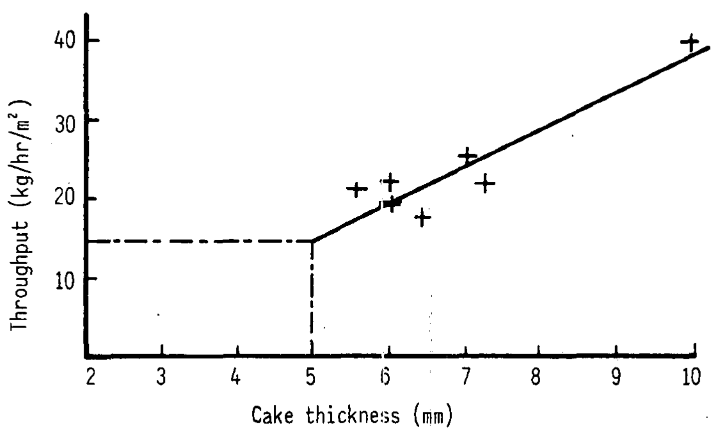

FIGURE 9 The relationship between cake thickness and throughput

By varying the length of the wash zone (by adding more or less water), the relationship between the quantity of wash water as expressed by the wash ratio and the pol % filter cake can be obtained. This is given in Figure 10. From this curve it can be seen that a wash ratio of 4 l/kg solids is required to give a pol % cake of less than 1%. It was found that a wash ratio in excess of 8 l/kg resulted in the filtrate brix dropping below the desired 6,5–7%.

Cake Drying: the drying zone is essential to obtain a cake that will discharge easily and can be handled by the mila disposal system. It was found that a cake of 20% solids was acceptable and that this could be obtained by using a drying cycle time of 40 s. The relationship between solids % cake and the drying cycle time is given in Figure 11.

Filtrate Quality: the clarity of the filtrate depends on the type of filter cloth used. In the test work the same cloth was used as in the smuts dewatering tests. With this cloth the filtrate contained 0,5 - 1% suspended solids. No work was carried out to try to optimize the type of cloth for this application.

The filtrate purities were very low, dropping to 50%, in the first few runs. This was due to the design of the filtrate receiver, which contained a large dead space below the filtrate pump offtake. The addition of a biocide resulted in the filtrate purities rising sharply, and an average purity of 78,2 was recorded for the last 24 hour run. In any future work the filtrate receiver would be designed with a conical bottom and a bottom offtake to eliminate the dead space.

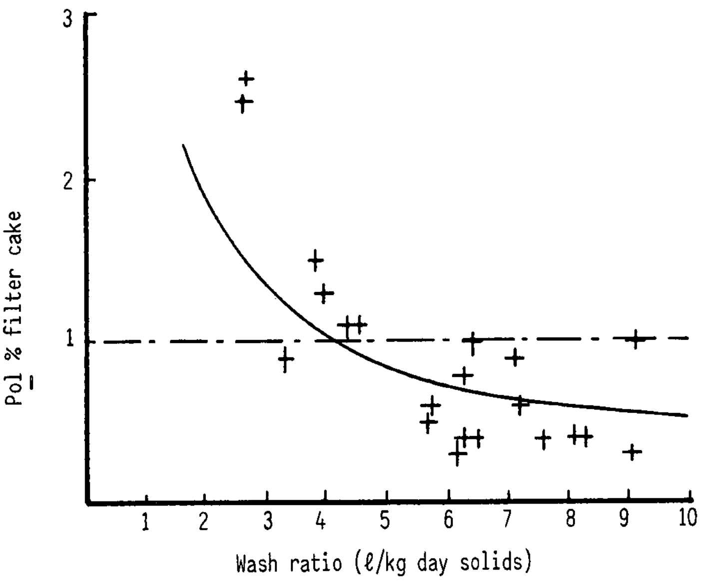

FIGURE 10 The relationship between wash ratio and the pol in cake

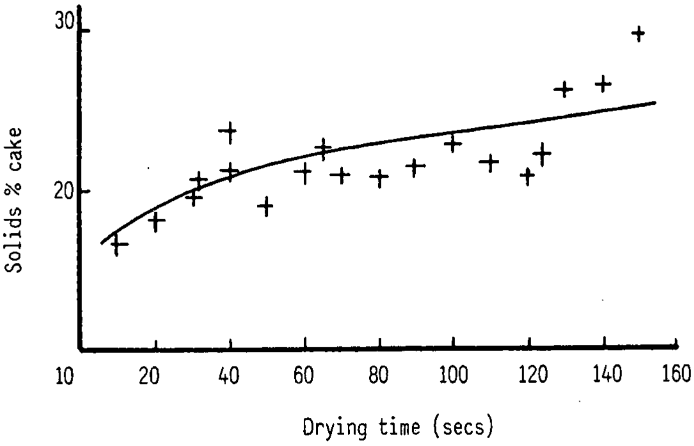

FIGURE 11 The relationship between drying time and the solid content of the cake

Blinding of cloths: it was found that no apparent blinding of the cloth occurred after 24 hours of continuous operation. It appears that the hot water sprays are effective in cleaning the cloth.

Vacuum sealing water: on a few occasions too much vacuum seal water was injected and this caused a marked drop in the filtrate brix. It was found however, that with the belt running at such a slow speed little water was required for the seal and it may even be possible to run without the addition of sealing water.

Flocculant addition: a number of commercial flocculants were tested in the laboratory and it was found that the improvement in performance was too marginal to justify further work on the plant in the time available.

Comparisons with the Rotary Vacuum Filter: as the pilot plant was installed in parallel with the 70 m² Dorr Oliver rotary drum filter, it was possible to make comparisons. These are summarised on Table 2. It should be noted that these results are merely an indication of the differences, as no optimization work on the rotary drum filter was carried out during these tests.

TABLE 2

Comparison between the HBF and the Rotary Drum Filter

	HBF	Rotary Drum Filter
Throughput (kg dry solids/hr/m²)	19,0	16,0
Solids % Cake	21,5	24,9
Pol % Cake	0,5	0,7
Filtrate Brix	6,6	7,1
Filtrate Purity	78,2	81,3

Conclusions

From the results of the tests on cane mud filtration it can be seen that the horizontal vacuum belt filter has great potential in this application. The advantages of counter current washing which are likely to improve further the performance of the filter have not been explored, and it is felt that further work in this area should be carried out.

Acknowledgements

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