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THE ELIMINATION OF FILTERCAKE IN A CANE SUGAR FACTORY BY RECYCLING DEFECATION MUDS TO THE EXTRACTION PLANT

By

C.R.C. JENSEN

Tongaat-Hulett Sugar Ltd, Glenashley, South Africa

Abstract

Mud recycle is a process option for cane sugar factories which eliminates the need for a filter station by using the bed of shredded cane in the extraction plant to separate mud solids from the juice. Mud recycle at diffuser factories in South Africa has proven very successful, and by the 2000 season most factories had switched to mud recycle. This paper describes the mud recycle system at Maidstone mill and discusses the performance of the system during the 1999 season. The benefits of mud recycle are presented in terms of both ease of operation and automation, and cost savings. Preliminary results from a mud recycle trial at a milling tandem factory are also presented.

Introduction

The basic premise for recycling clarifier mud to the extraction plant is to use the filtration capability offered by shredded cane to separate suspended solids from the mud. In this way, rotary vacuum-filters and the bagacillo supply system for mud-filtration are eliminated. The suspended solids are carried along with the bagasse to the boilers where the combustible portions are incinerated and the non-combustible portions become boiler ash.

The idea of mud recycle is not a new one. In Java during the 1930s mud recycle was successfully implemented at factories with milling tandems. It was found that juice clarification became more difficult and the sucrose content of the bagasse increased. However, eliminating the loss of sucrose in filtercake compensated for the lower extractions (Tromp, 1936).

The bed of shredded cane in a diffuser has a greater filtration capability than the shredded cane in a milling tandem. The low suspended solids % mixed juice at diffuser factories compared to factories with milling tandems is evidence of this. Lamusse (1980) attempted to perform the entire clarification operation in a diffuser, which would eliminate the need for both clarifiers and filters. However, problems with increased colour formation, when clarifying at high temperatures, and with post-precipitation, when clarifying at lower temperatures, resulted in the practice being discontinued. These problems are avoided with Clarifier mud recycle as only the filtration step is replaced.

The potential for implementing mud-recycle has existed in the South African industry since the installation of the first diffuser in 1965. However, it was only in 1997 that the first mud recycle trials were carried out at a cane diffuser factory (Meadows *et al.*, 1998). The trials were carried out at Maidstone mill and lasted for three weeks in total. These trials proved that mud recycle provided a viable alternative to a filter station, and no negative impacts in terms of juice quality or extraction were detected.

As mud recycle has an impact on the cane payment system in South Africa, it was necessary to obtain approval from the South African Sugar Association (SASA), before further mud recycle trials could be carried out. Once this was granted, a second mud recycle trial commenced at Maidstone in October 1998, and continued for some three months until the end of the crushing season. The aims of the second mud recycle trial were firstly, to assess mud recycle over a longer trial period, and secondly, to determine the accuracy of the analytical procedures drafted by SASA for mud analysis. A thorough assessment of these procedures was required before mud recycle could be approved on a permanent basis. A detailed assessment of the impact of mud recycle on factory performance and of the analytical methods proposed by SASA to measure the impact of mud recycle on cane payments is reported elsewhere (Jensen and Govender, 2000). In summary, it was found that:

- Mud recycle had no measurable impact on juice purities, sucrose losses in the diffuser, or on the factory undetermined loss.
- Mud purities increased as a result of mud recycle.
- There was no evidence of a decline in extraction as a result of mud recycle.
- Suspended solids in clear juice and clear juice quality were unaffected by mud recycle.
- The prescribed methods for massing, sampling and analysis of the mud were verified by comparing them with different sampling techniques, independent analysis methods and composite sample analysis.

On the basis of this and other successful mud recycle trials at Malelane and Komati mills, SASA approved the implementation of mud recycle at South African mills in April 1999 (Brokensha, 1999). By the end of the 2000 season, most diffuser factories in South Africa had switched to mud recycle. In addition, the success of mud recycle at diffuser factories has rekindled interest in attempting mud recycle on milling tandems.

KEYWORDS: Mud Recycle; Diffuser; Milling Tandem; Filter Cake.

This paper describes the mud recycle system at Maidstone and discusses the experiences with mud recycle during the 1999 season. The benefits of mud recycle are summarised, and the value of these benefits to Maidstone during the 1999 season are estimated.

Maidstone mud recycle system

Figure 1 shows a process flow diagram of the mud recycle system at Maidstone. Maidstone has two diffusers: a Tongaat-Hulett design diffuser which is rated at 300 t cane/h (shown in Figure 1), and a BMA design diffuser which is rated at 200 t cane/h. After weighing separately, the two draft juice streams are combined and pumped through the mixed juice heaters to a flash tank. Lime is added prior to flashing and juice flows by gravity from the flash tank to two Dorr-type clarifiers, each of which has four mud offtakes. The mud withdrawal system is automated, with mud being withdrawn from each of the mud compartments in sequence, to a common standpipe. The standpipe is fitted with a level transmitter to ensure that a constant volume of mud is withdrawn from each compartment. (Once the mud level in the standpipe reaches the high-level set-point, the mud-valve from that compartment closes. As the mud continues to be pumped from the standpipe the mud level drops, and on reaching the low-level set-point mud is then withdrawn from the next mud compartment in the sequence.) The mud is pumped from the standpipe to the mud scale where it is weighed and sampled.

After weighing, the mud is recycled to either the Tongaat-Hulett or the BMA diffuser. From a processing point of view, the mud stream should theoretically be split between the two diffusers in proportion to the cane throughput on each tandem. This would ensure an approximately equal mud load for each diffuser bed, thereby minimising the impact of mud recycle on juice percolation in the diffusers. However, as the juice from each diffuser is weighed and analysed separately, this would complicate the cane payment system. Fortunately, the experience at Maidstone is that either diffuser has sufficient filtration capacity to cope with all the mud from both tandems. It is unlikely that the additional cost of splitting the mud stream and weighing each of the streams separately could be justified in terms of increased extraction.

In order to distribute the mud evenly across the bed of cane, the mud is pumped directly into the suction side of one of the diffuser recirculation pumps, thereby avoiding the need to install a mud distribution system in the diffuser. As discussed by Meadows *et al.* (1998), the position where the mud is returned to the diffuser is important:

- Firstly, to minimise the impact on the juice concentration gradient in the diffuser, the mud should be returned as close to the draft juice trough as possible. (The brix of the juice in the mud is the same as that in draft juice.)
- To ensure good filtration, the mud should be added where the bed is well established.
- To prevent the mud blinding the bed, which would reduce juice percolation through the bed and possibly result in flooding of the diffuser, the mud should be added where the bed is not too heavily compacted (*e.g.* near a set of lifting screws).

The location best satisfying these criteria, as shown in Figure 1, is the recirculation pump that delivers juice to the sprays positioned immediately before the first set of lifting screws.

The pumps used for recycling the mud are centrifugal pumps, with a non-choking open impellor design. Mud is highly corrosive/erosive and both the pump impellor and the mud recycle pipework have

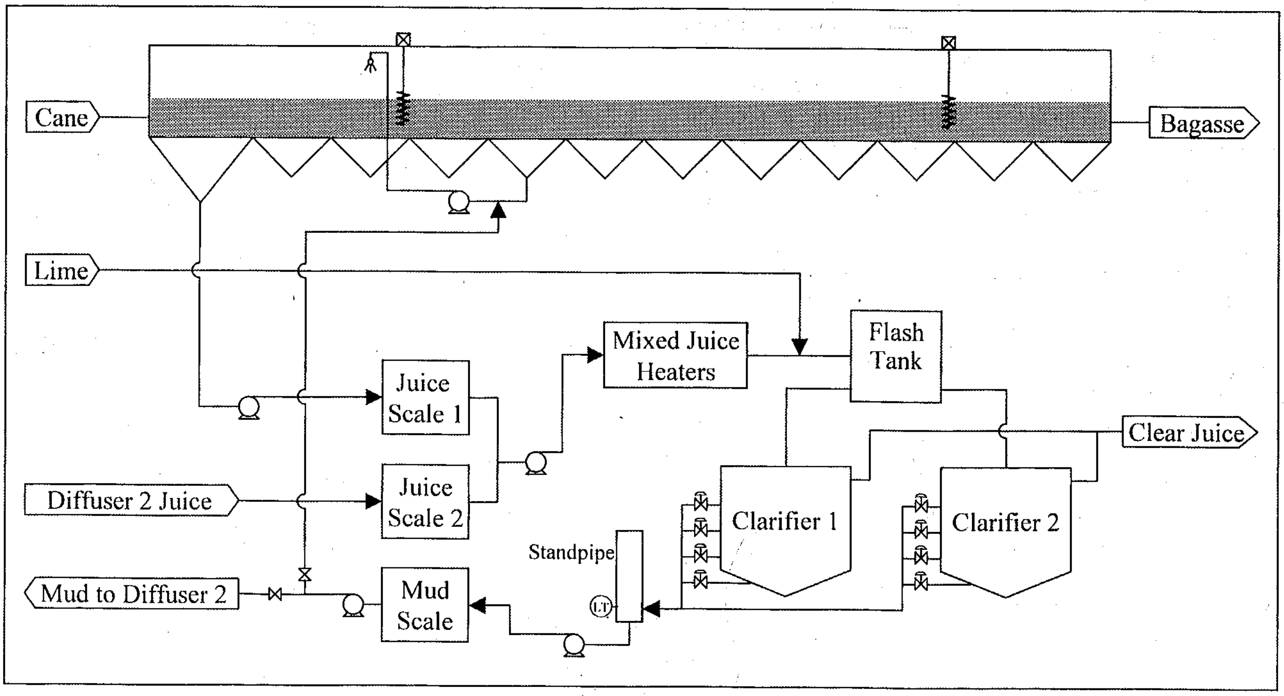

Fig. 1—Maidstone mud recycle system.

been replaced with stainless steel since the first trial in 1997. The mud recycle pumps were sized to pump a maximum of approximately 30 t mud/h. The average mud flow rate during the 1998 trial was 15 t/h. Therefore the mud recycle system has sufficient excess capacity to reduce the clarifier mud levels, even at maximum crush rates.

Mud recycle during 1999 season and mud consistency control

The implementation of mud recycle at Maidstone was largely uneventful. Initially there were a few instances of juice flooding in the diffusers, but these were caused as much by incorrect spray position and shredded cane quality as by mud recycle. The only time when a reduction in percolation rate through the diffuser bed (as a direct result of mud recycle) was noticeable, was when both tandems were crushing and all the mud was recycled to the smaller diffuser.

Maidstone in the past used to struggle with high mud levels in the clarifiers, caused by poor mud filterability, and the associated sucrose losses. With mud recycle, this limitation on the mud withdrawal rate was removed, and it was possible to run with very weak muds, e.g. <2% mud solids. Mud levels were maintained at 'zero' with relative ease and mud temperatures rarely dropped below 98°C. With mud recycle the problems of high mud levels in the clarifiers were effectively eliminated. Figures 2 and 3 show the mud-solids % mud and the mud % mixed

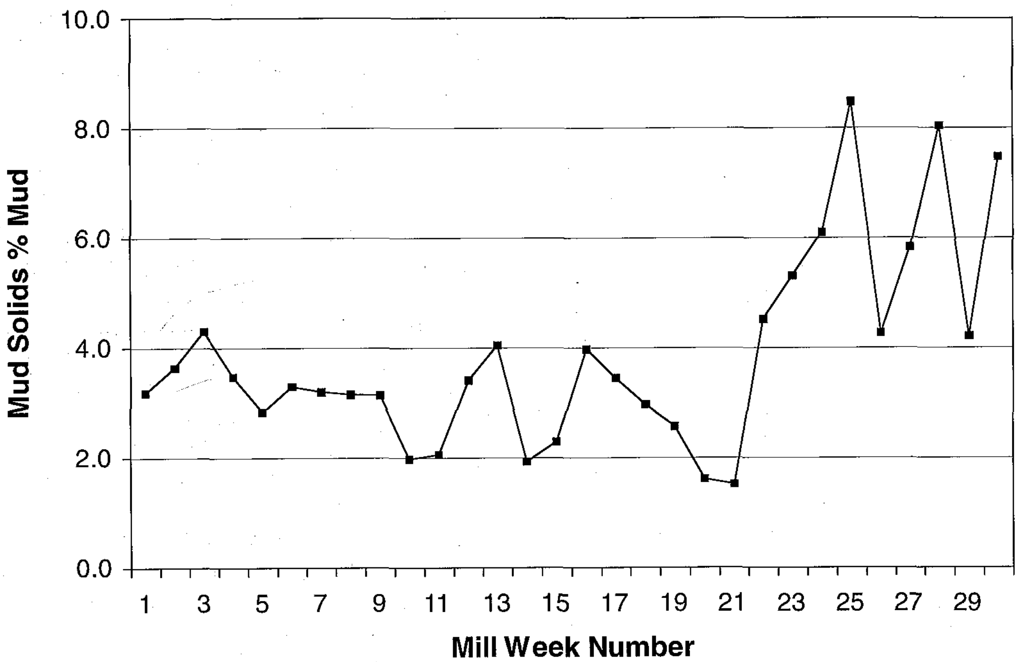

Fig. 2—Graph of mud solids % mud at Maidstone during 1999 season.

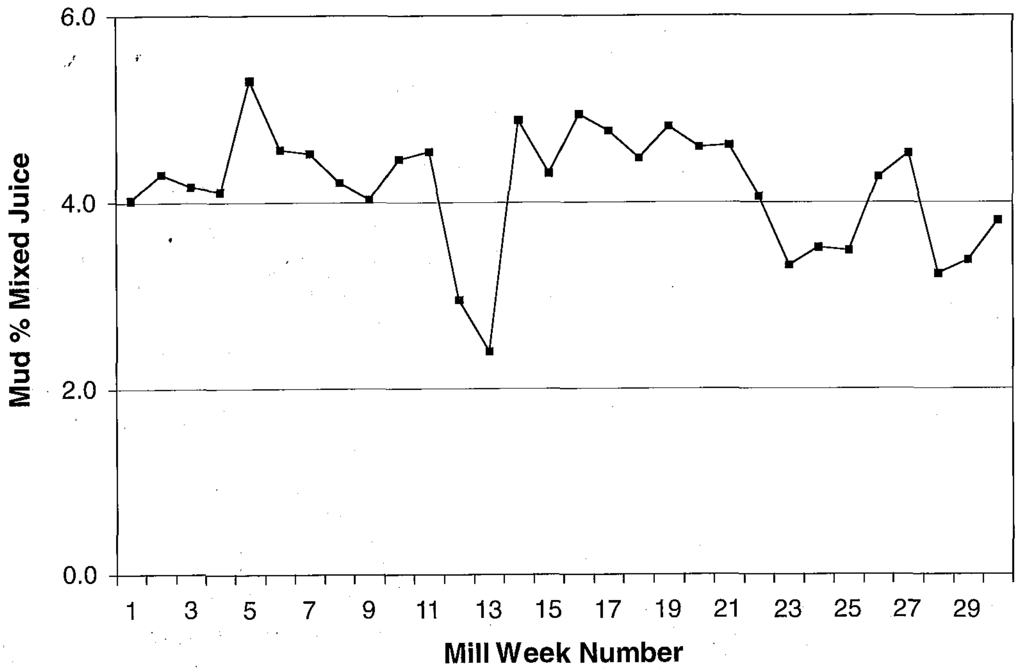

Fig. 3—Graph of mud mixed juice at Maidstone durng 1999 season.

juice for the 1999 season. For the majority of the season, the mud-solids % mud withdrawn from the clarifier ran at about 3%, and the percentage underflow from the clarifier was greater than 4%. This is evidence of the recycle of weak muds

The relative ease with which mud may be withdrawn from the clarifier with mud recycle introduced a new problem at Maidstone: 'juice recycle' to the diffusers. The pumping capacity of the mud recycle system increases as the muds become thin. Therefore, once a compartment has been emptied of mud, juice will continue to be recycled from that compartment at a high flow rate. Juice recycle has the following problems:

- Distorts the diffuser brix profile, and hence can affect extraction.
- Results in higher mixed juice flows, and hence increases the hydraulic load on the clarifiers.

To minimise juice recycle, operators would take a compartment out of sequence when the muds became too thin. They would then check the mud consistency in that compartment at regular intervals, and switch the compartment back into sequence once the mud had thickened again. Operating in this fashion required a high level of operator involvement and judgement, and resulted in both juice recycle, when a compartment was kept in sequence for too long, and mud deterioration, when a compartment was left out of sequence for too long.

In order to eliminate the need for operator intervention (to ensure that the muds do not become too thin), an on-line measurement of mud consistency was required. Gooch (1994) developed a flow-through method for measuring the consistency of clarifier muds. The method is based on the principle that, at a constant head and temperature, the mud flowrate through a venturi depends on its consistency. Tests carried out at Mt. Edgcombe Mill proved this method to be suitable for on-line mud consistency measurement. At Maidstone it was observed that the time taken for mud from each compartment to fill the mud standpipe depended on the consistency of the mud in that compartment. Measuring the time to fill the mud standpipe produced repeatable results for muds of similar consistency. (This is effectively an indirect method of measuring the mud flowrate.) By sampling the mud, it was possible to determine the relationship between the mud withdrawal-time and the actual mud consistency for each compartment. This method of mud consistency measurement formed the basis of an automatic consistency control system implemented at Maidstone during week 21 of the 1999 season. The impact of the consistency control system is evident in Figures 2 and 3: Figure 2 shows a sharp increase in the mud solids % mud from about 3% to between 6 and 7%, while Figure 3 shows a drop in the mud % mixed juice. In addition to eliminating the need for operator involvement, the control system solved both the problem of mud deterioration in the clarifiers and that of juice recycle. It enabled the mud solids % mud to be controlled, whilst maintaining mud temperatures greater than 98°C and mud levels at zero.

Mud recycle effectively changes the nature of the instrumentation requirements for clarifier control. In the past, much focus was given to developing instruments for measuring the mud levels in clarifiers, in an effort to eliminate mud build-up. With mud recycle the focus has shifted to the other end of the spectrum, *i.e.* preventing excessive juice recycle along with the mud. Before mud levels increase in a clarifier, the mud will begin to thicken; which will be identified by a change in mud consistency. This explains how consistency control is able to eliminate excessive juice recycle, whilst maintaining 'zero' mud levels.

Weeks 12 and 13 in Figure 3 show a sudden drop in the mud % mixed juice. A long factory stop occurred in week 12, and the clarifier muds became very thick. The thick muds reduced the capacity of the mud recycle system so significantly that the mud pump 'struggled' to drop the mud-levels in the clarifiers. The system was eventually cleared by diluting the mud in the standpipe with water.

Figure 4 plots the difference between the mixed juice purity and the mud purity for the 1999 season. Week 13 shows the impact of high mud levels as a result of the long factory stop on the mud purity: mud purities of more than 5 units lower than mixed juice purity. With the implementation of mud consistency control in week 21, there was a sudden decline in the purity difference between mixed juice and mud from greater than two units to zero, and for the remainder of the season the purity difference was actually negative. Obviously it does not make sense for the mud purity to be higher than the juice purity. This was a result of an approximation (Jensen and Govender, 2000) in the analytical method for mud pol analysis, which has subsequently been corrected. (The result of the approximation is that the difference between the mixed juice and mud purities are exaggerated, both before and after week 21. Nevertheless the impact of mud consistency control on mixed juice minus mud purity is clear.)

The benefits of mud recycle at a diffuser factory

The following list summarises the primary benefits of mud recycle:

1. Reduced capital, maintenance and operational costs by eliminating the filter station and all ancillary equipment (bagacillo separation and conveying system, filtercake conveying and storage facility).
2. Reduced physical and chemical sucrose losses. At a typical diffuser factory about 0.2% of the sucrose entering the factory leaves the factory in the filtercake. Mud recycle eliminates this physical loss of sucrose. Furthermore the chemical (bacteriological) losses associated with filter station operation are also eliminated. (Bacteriological losses under mud recycle are negligible as mud temperatures close to 100°C can be maintained.)
3. Reduced evaporation requirements as the water used for washing the filtercake is eliminated.

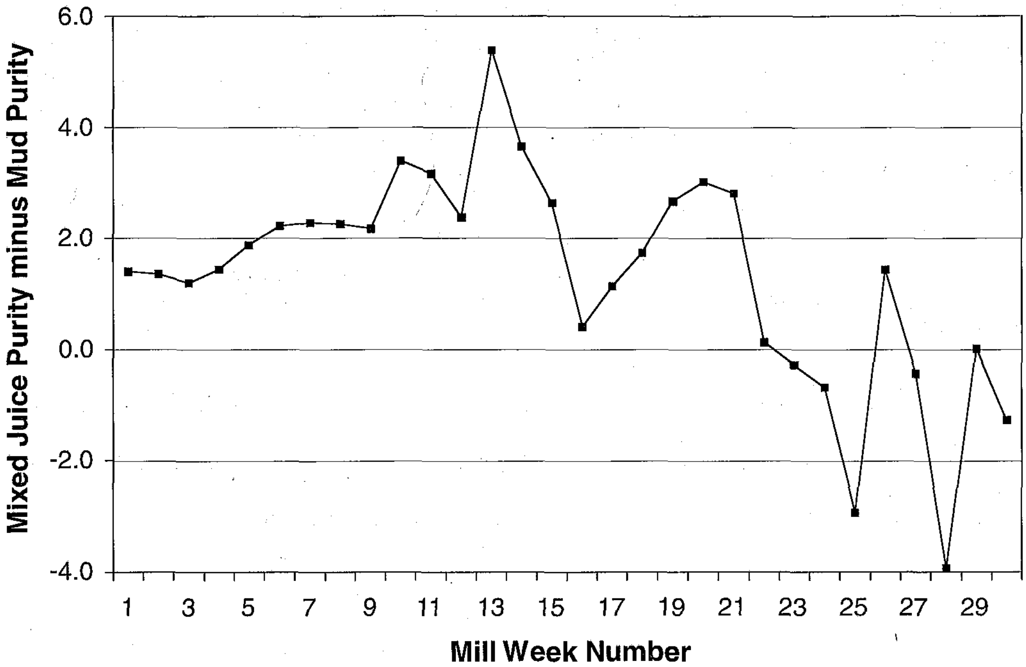

Fig. 4—Purity difference between mixed juice and mud at Maidstone factory, 1999 season.

4. Reduced solid waste disposal costs with the elimination of filtercake.
5. Increased supply of fuel to the boilers.

In an attempt to quantify the benefits of mud recycle to a typical sugar factory, Table 1 includes the estimated cost savings at Maidstone during the 1999 season as a result of mud recycle. In 1999, Maidstone produced 190 000 t of sugar. The savings will obviously vary significantly from factory to factory.

Table 1—Estimated cost savings of mud recycle (Maidstone 1999 season).

Item	Saving (USD)
Reduced maintenance costs	$20 000 p.a.
Reduced operational costs	$20 000 p.a.
Reduced physical losses (using industry average figure for sugar loss in filtercake for the 1999 season)	$85 000 p.a.
Reduced chemical losses (assuming a 0.02% undetermined loss in a typical filter station)	$10 000 p.a.
Reduced solids waste disposal costs	$70 000 p.a.
Reduced losses in bagasse (through approximately a 5% increase in imbibition)	$15 000 p.a.
Total costs savings:	$220 000 p.a.

The main disadvantages of mud recycle are:

1. The additional sand that is carried to the boilers increases the abrasion of boiler tubes. However, for diffuser factories the increase is less than 10% of the sand that is already carried with the bagasse to the boilers.
2. An additional mass meter is required to weigh the mud before recycling.
3. The loss of filtercake means a loss of nitrogen to the soil. However, recent studies have shown that boiler smuts (flyash, sand combination) alone still has value as a fertiliser, primarily because of its soluble silica content (Meyer and Keeping, 2000).

Mud recycle to a milling tandem

During the 2000 season, a three week mud recycle trial was carried out at Darnall Mill (the only Tongaat-Hulett factory which still has a milling tandem). At Darnall, the mud was simply returned to the swirl tank between the 4th and 5th mills in the 7 mill tandem. It was found that both the suspended solids % mixed juice and the pol % bagasse increased by approximately 0.15%. (Neither of these impacts is evident with diffuser mud recycle.) However, despite the increased solids load on the clarifiers, clear juice quality was not affected; and there seemed to be a small improvement in the overall recovery (*i.e.* the increased boiling house recovery as a result of eliminating filtercake was greater than the additional losses in extraction). Further trials are planned for the 2001 season.

Conclusions

Mud recycle at diffuser factories in South Africa has proven to be a simple processing alternative to the traditional filter station. The paper has shown both the benefits and the ease with which clarifier mud withdrawal can be automated under mud recycle. Under mud recycle the potential also exists for simplifying the cane payment system by eliminating the suspended solids analysis on mixed juice (Jensen and Govender, 2000).

By the 2000 season almost all the diffuser factories in South Africa had switched to mud recycle, and have enjoyed similar benefits to Maidstone. However, the main benefits of mud recycle will only be realised with the construction of a new sugar mill, where the capital costs associated with a filter station are eliminated altogether.

Further work in South Africa is planned to determine the comparative benefits of implementing mud recycle on factories with milling tandems.

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ÉLIMINATION DU TOURTEAU DE FILTRE DANS LA SUCRERIE DE CANNE EN RETOURNANT LES BOUES DE DÉFÉCATION A L'ATELIER D'EXTRACTION

C.R.C. JENSEN

Tongaat-Hulett Sugar Ltd, Glenashley, South Africa

Résumé

Le retour des boues a la diffusion permet la fermeture de la station filtres. Le tapis de canne shreddée remplace les filtres pour séparer les matière solides des boues. En Afrique du Sud, le retour des boues aux diffuseurs a été adopté avec succes par plusieures sucreries. Le papier décrit ce systeme a Maidstone et donne les résultats obtenus en 1999. Les avantages obtenus sont de meilleures performances, une opération aisée, et des couts d'opération réduits. Le retour des boues aux moulins dans une autre sucrerie, est aussi discuté.

Mots clefs: Recyclge des boues, diffusions, moulins, tourteau.

LA ELIMINACIÓN DE LA TORTA DE CACHAZA EN UN INGENIO RECICLANDO LA CACHAZA DEFECADA EN LA PLANTA DE EXTRACCIÓN

C.R.C. JENSEN

Torgart-Hulett Sugar Ltd, Glenashley – Sur Africa

Resumen

El reciclaje de cachaza es un proceso para ingenios, que da la opción de eliminar la estación de filtros usando la camada de caña desmenuzada en la planta de extracción para separar los solidos de la cachaza defecada del jugo. El reciclaje de cachaza en ingenios con difusores en Sur Africa ha sido comprobado como un sistema provechoso; en la zafra del 2000 la mayoría de los ingenios, en este país, cambiaron a ese sistema. Esta presentación describe el método de reciclaje de cachaza en el ingenio Maidstone y analiza los resultados del sistema durante la zafra de 1999. Los beneficios se presentan en términos de facilidad de operación, automatización y ahorros de costos. Son tambien presentados resultados preliminares de una prueba de reciclaje de cachaza en un ingenio con un tandem de molinos.

Plabras claves: Reciclaje de cachaza, difusor, tandem de molinos y torta de cachaza.