OPTIMISATION OF REFINERY PRESSURE LEAF FILTER PERFORMANCE BY DOSAGE OF FILTER AID INTO THE FILTER FEED STREAM

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Abstract

The Malelane refinery decolourisation process comprises a primary carbonatation step followed by filtration through pressure leaf filters and a secondary light sulphitation step, again followed by filtration through another set of pressure leaf filters. Although the resultant refined sugar colour obtained with this process is adequate, the levels of turbidity and insoluble solids in refined sugar have been problem areas. Analysis of the filtered residue in refined sugar pointed to calcium sulphite as the main cause of turbidity and insoluble solids. The source of the residue was traced to break-through of minute amounts of calcium sulphite during the filtration process.

Conventional pre-coating practise involves making a suspension of filter aid in condensate and then depositing a layer of filter aid onto the filter membrane by recycling flow through the filter. The filtration process only commences once this primary media is established.

This paper reviews steps taken at Malelane refinery to optimise performance of the pressure leaf filters by:

- An initial high dose of filter aid directly into the filter feed stream to build up a primary filtering media on the filter cloth surface.
- A continuous lower dosage of filter aid is maintained to ensure porosity of the cake as it builds up during the filtration cycle.

The benefit of this technique is that it is a 'quick fix' that provides a simple, low cost dosage plant, significantly longer filter cycle time and improved refined sugar quality.

Keywords: filtration, sugar colour, decolourisation, turbidity, insoluble solids

Introduction

The Malelane refinery decolourisation process comprises a primary carbonatation step followed by filtration through pressure leaf filters and a secondary light sulphitation step again followed by filtration through another set of pressure leaf filters. Although the resultant refined sugar colour obtained with this process is adequate, the levels of turbidity and insoluble solids in refined sugar have been problem areas for several years. This quality aspect is important to industrial users who use refined sugar to manufacture clear or light coloured products. The Malelane Industrial Market specification for these parameters is a turbidity reading of <10 at 720 nm and an insoluble solids level of <10 ppm.

Measurement of turbidity and insoluble solids in sugar

Turbidity and insoluble solids are a measure of suspended matter in refined sugar. The turbidity measurement is either a visual haze method or a spectrophotometric technique that gives an indication of suspended matter in a sugar solution. Insoluble solids also measure suspended matter; however, it is a gravimetric technique. Lightweight suspended matter in sugar, like bagacillo, will influence the turbidity reading more than the insoluble solids reading and, *vice versa*, a heavy contaminant like a rust spec will influence the gravimetric reading more than the turbidity reading. Initial work done to address this quality aspect concentrated on eliminating airborne contaminants, mainly bagacillo and boiler flue gas particulate matter from the pan house building (Singh and Seed, 1998). This approach yielded only a small improvement.

Filter automation

A common denominator in the turbidity and insoluble solids problem was high filter pressures and short filter cycles, particularly in the final filtration step. Given this scenario, management refocused attention on filter performance. The first phase of this drive was to reduce operator errors. In this regard, Malelane mill opted for partially automating the pressure leaf filters.

In summary, the control philosophy adopted is based on regulating the flow into the filter. The end of cycle is terminated at a pre-set pressure limit. Filtrate turbidity is measured with an SMRI-designed online turbidity meter for each filter. An arbitrary turbidity set point value determined by filter disc tests is used to accept/reject the filtrate. With this mode of operation, the levels of insoluble solids in refined sugar averaged 10 ppm, with occasional peaks of 15-20 ppm. In the latter instance, third and fourth boilings refined sugar would be rejected, with resultant capacity reduction. Analysis of the filtered residue in refined sugar pointed to calcium sulphite as the main cause of turbidity and insoluble solids. Notwithstanding the performance limitation, the main benefit of the automation is that it has provided management with better diagnostic information that pointed to filtrate being accepted at too high a turbidity level at the start of cycle and intermittent break-through of minute amounts of calcium sulphite during the filtration process. This information predicated attention to the actual filtration process.

Principle of filtration

Filtration in a pressure leaf filter is essentially the traditional practise of solids retention on a porous filtration medium supported on a permeable membrane. This permeable membrane is generally a polypropylene filter cloth which in turn is supported on a rigid frame. The rate of filtration is determined by the porosity of the filter medium and by the pressure difference (ΔP) between the inlet and outlet streams. The trade-off between filtration efficiency and throughput is a function of the porosity of the filter media. The finer the porosity of the filtering medium, the more efficient is solids retention at the expense of resistance to liquid flow. The relationship between porosity and filtration rates is illustrated in Figure 1 (Gabba, 1998).

Filter operating technique

The filter operating technique employed at the Malelane refinery uses the precipitate formed during carbonatation and sulphitation to form a primary filter media or pre-coat on the filter cloth surfaces. This involves recycling unfiltered liquor through the filter. Initially only coarse precipitated aggregate will be retained on the cloth surface.

With subsequent passage of unfiltered liquor, the trapped coarse media will in turn retain medium sized particles and these in turn, once established, will retain progressively smaller and smaller sized particles. The pre-coating process takes approximately 30 to 60 minutes and, during this period, the highly turbid filtered liquor stream is rejected to the feed tank. Only when the filtrate is free of turbidity is the filtrate accepted and the filter can be said to be online. This technique does not require pre-coating with conventional filter aid and thereby obviates the need for a pre-coating plant and minimises operating costs.

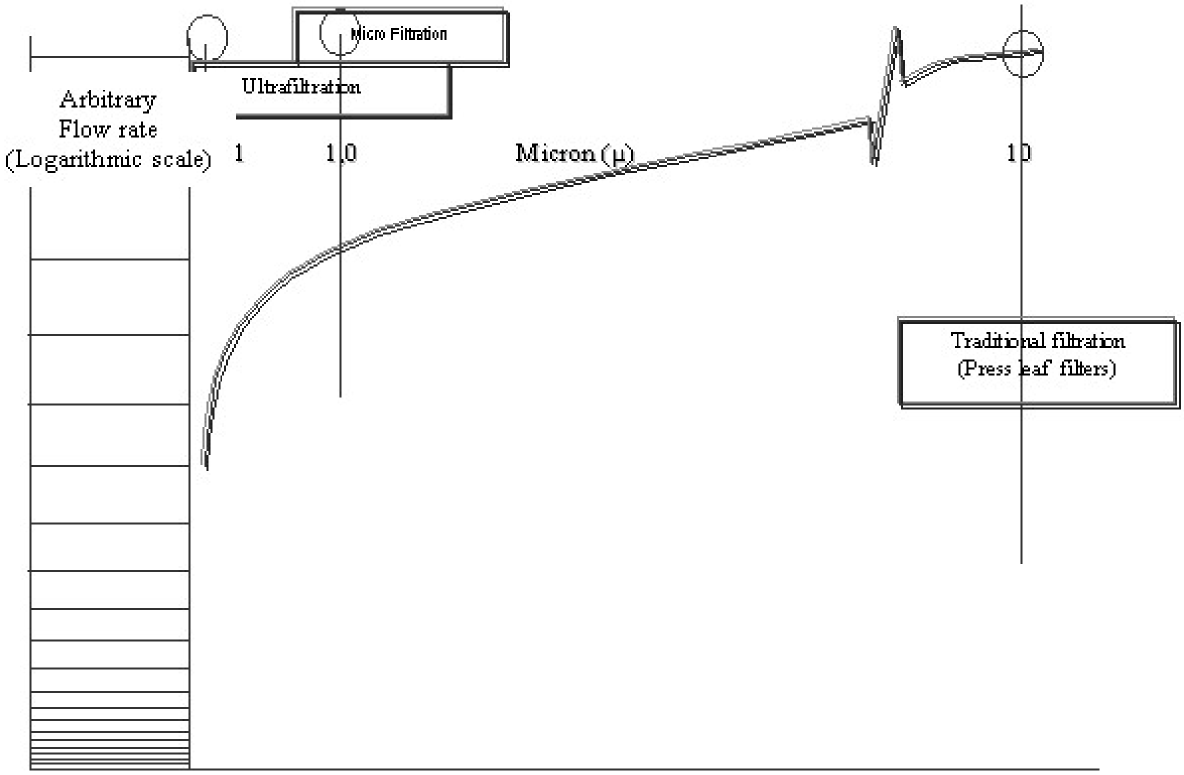

Figure 1. Typical relationship between porosity and flow rate.

Filter aid

Different options were considered to improve filtration efficiency. The installation of a polish filter was considered the best solution; however the capital cost of additional filters was considered to be prohibitive. Pre-coating was considered the next best option. As a prelude to installing a full pre-coating plant, refinery technical personnel opted to run pre-coat trials.

The filtering characteristics of commercially available filter aid can be summarised briefly as follows:

- Diatomaceous earth (commonly known as Kieselgur and Celite) is characterised by a high primary and secondary interstitial volume.
- Perlite is similar to diatomaceous earth; however, it has a lower density and as such offers a 20-30% saving in mass in comparison to diatomaceous earth.
- Composite filter aid comprising a blend of diatomaceous earth, perlite and cellulose fibres is characterised by increased interlacing which offers a higher resistance to crumbling and cracking and thereby creates a stable alveolar structure.

Due to pressure to meet the refined sugar quality and capacity requirement, it was decided to commence trials with a product that would not compromise this aspect. This meant choosing a filter aid with good solids retention and satisfactory permeability. Positive results at other sugar refineries using a cellulose fibre/perlite/diatomaceous earth complex convinced TSB personnel of the merits of commencing plant trials with this type of product. The permeabilities of typical filter aids used in sugar refinery applications are shown in Table 1 (Gabba, 1998).

Table 1. Comparison of permeability rates for various filter aids.

Filter aid	Permeability (L/m^2/min)
Fibroxcel (complex)	63 - 215
Celite	450 - 1050
Perlites	68 - 240
Diatomaceous type	50 - 1150

Pre-coat plant design

In order to incorporate a pre-coat step into the filter cycle, a temporary installation was done comprising two 1 m^3 polypropylene containers, a dosage pump and the associated pipe work, as shown in the PFD in Figure 2. Filter aid was de-bagged manually via a large funnel into one of the 1 m^3 polypropylene containers and an air sparger was used to keep the filter aid in suspension. The pre-coat step was operator controlled and involved intensive dosing of filter aid into the filter feed stream during the pre-coat step. The time taken to dose 500 litres of filter aid suspension was timed to coincide with the end of the pre-coat cycle, generally 15-20 minutes. A continuous dosage of filter aid was dribble fed into the suction of the filter supply tank from the other 1 m^3 polypropylene container.

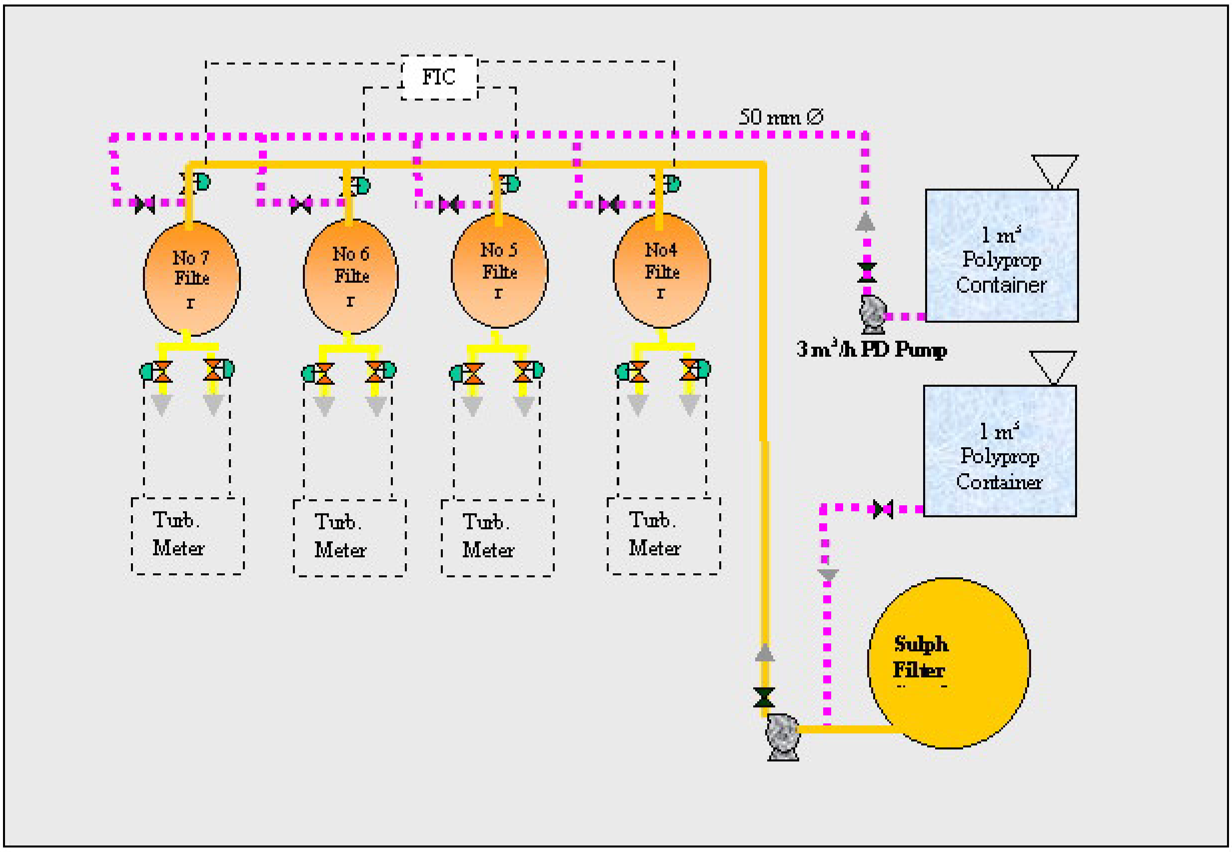

Figure 2. PFD of Malelane sulphited filter station.

Results and discussion

The trial was conducted in September 2002. Average data before and after the trial was used to evaluate the effectiveness of the filter aid.

Ten kilograms of filter aid was used for pre-coating a single 117 m^2 filter. Continuous dosage of filter aid was maintained at rate of 20-25 ppm into the common filter feed stream.

The trials have led to the following conclusions, which are illustrated in Figures 3 to 7.

- The online filter time of the sulphited filters is on average 55 hours and peaked to ~130 hours as a result of pre-coating. Prior to the use of filter aid, the average online time of the sulphited filters was 6-10 hours.
- The fine liquor turbidity has decreased by about 70%.

Downstream benefits include:

- A reduction in the insoluble solids and turbidity levels in refined sugar.
- A reduction in sugar losses in de-sweetened refinery sludge. This is believed to be the result of the residual filter aid in sweet sludge improving the filterability of the final pressed filter cake. The sucrose % sludge decreased from 0.9 to 0.7%.
- An improvement in the refinery capacity due to sugar quality being within specification.
- With the refined sugar quality specification and throughput constraints addressed, refinery personnel have now been able to examine other areas of optimisation. One such area has been the reduction of CaO levels required for carbonatation. CaO levels have been gradually cut back from the 8500 ppm level to a 6000 ppm level without any adverse affects on decolourisation. The benefit of this reduction translates directly into lime cost reduction. An added benefit has been a reduction in the CO_2 demand. This has allowed one gas pump to be shut down with concomitant savings in power and maintenance. The filter operation has improved as a result of using filter aid as shown in Figure 6. The reduction in the quantity of carbon dioxide is shown in Figure 7.

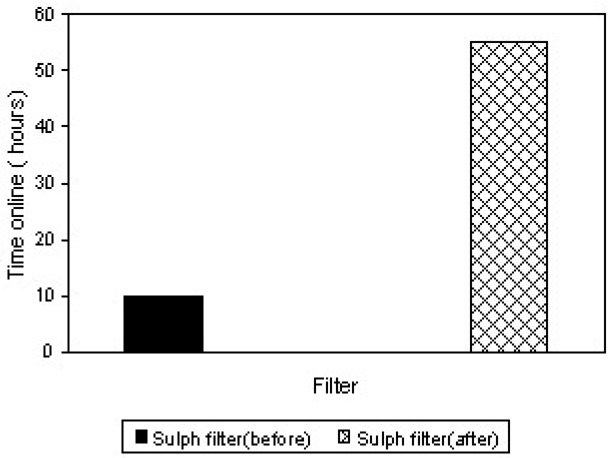

Figure 3. Average online time of filters.

Figure 4. Turbidity of fine liquor.

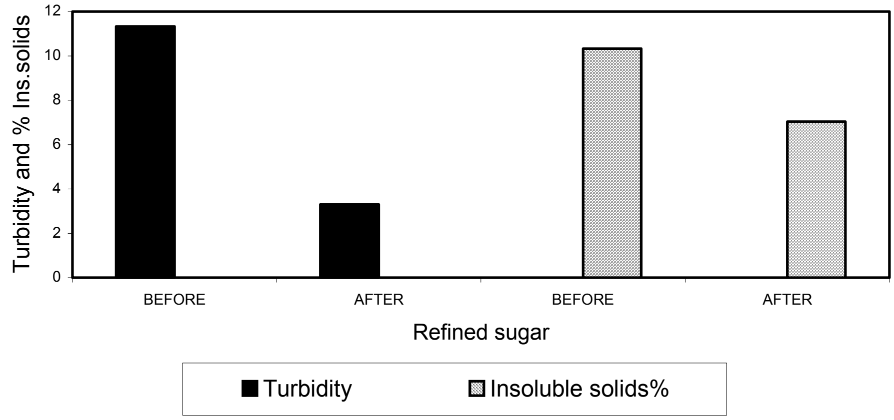

Figure 5. Turbidity and insoluble solids of refined sugar.

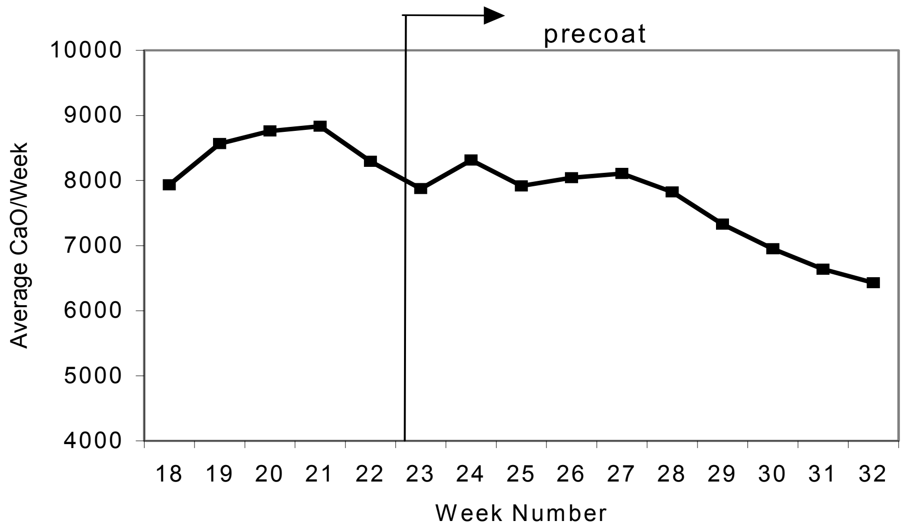

Figure 6. Lime consumption.

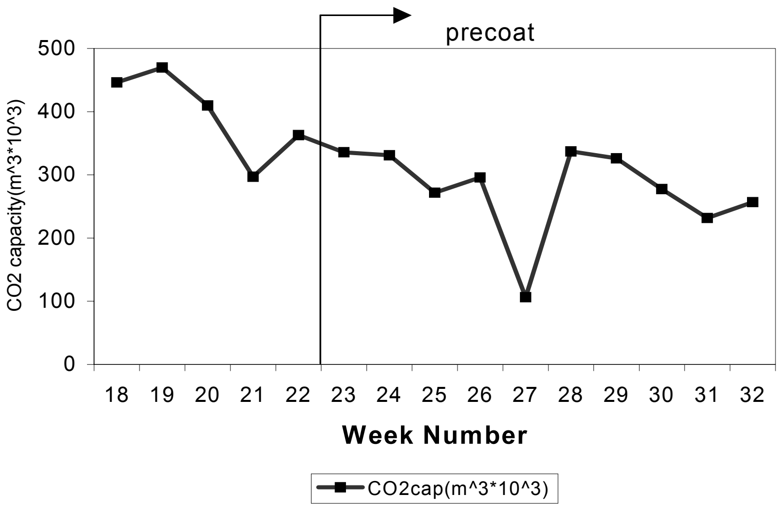

Figure 7. Carbon dioxide consumption.

Financial implications

The annualised cost/benefit analysis associated with using filter aid as a pre-coat is summarised in Table 2.

Table 2. Filter aid cost/benefit analysis.

	Rands
Sugar recovery from refinery sludge	500 000
Reduced lime usage	375 000
Savings on CO_2 pump maintenance	250 000
Gross savings	**1 125 000**
Cost of filter aid	600 000
Net savings	**525 000**

Conclusions

The automation of the filter station has provided management with diagnostic information, which has been used to optimise the filter performance.

The use of filter aid as a pre-coat at the Malelane refinery has shown the following benefits:

- High dosage of filter aid into the filter feed during the pre-coating stage, supported by continuous low dosage of filter aid during the filtration stage, has provided a 'quick fix' for eliminating solids contamination in filtrate.
- A simple low cost plant for filter aid mixing and dosage has been successfully incorporated into the filter station.
- The online cycle time of the sulphited filters has increased significantly.
- The turbidity and insoluble solids levels in refined sugar have decreased.
- Refined sugar tonnage, which was previously compromised due to poor quality, has normalised. The capacity improvement is estimated to be approximately 10%.
- Potential savings for sucrose recovery from sludge, reduction in lime usage, reduced CO_2 and quality benefits discussed in the report have been realised. These will offset the costs of filter aid.

Given the success and ease of application of the pre-coating technique, Malelane refinery has plans to extend the concept to the carbonatation filters.

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