

STEPS TAKEN AT MALELANE REFINERY TO IMPROVE REFINED SUGAR QUALITY

M MOODLEY AND PM SCHORN

Transvaal Sugar Limited, PO Box 47, Malelane, 1320

Abstract

The refinery at Malelane has in the past produced refined sugar for the consumer market. A decision was taken by the management of Transvaal Sugar (TSB) to produce a quality of refined sugar that would also be acceptable to the industrial and the export markets. The processes that were evaluated and implemented at the Malelane refinery during the past three seasons to achieve this objective, are described.

Keywords: sugar quality, Malelane

Introduction

To be competitive on both the local and export markets, it was necessary for TSB to improve the quality of refined sugar produced at the Malelane (ML) refinery. A refinery survey done by the Sugar Milling Research Institute (SMRI) (Moodley and Hastie, 1994) noted the following:

- pH values measured at the saturators were erratic and indicated poor control.
- The pH value of the liquor leaving the carbonation station was too high, showing a shortage of carbon dioxide gas.
- Colour removal during carbonation was low (30%).
- Washing at the refinery centrifugal needed to be optimised.
- The pH of sulphited liquor varied widely.

To improve sugar quality it was necessary for the ML refinery to optimise carbon dioxide supply, pH control and colour removal, and thereafter to evaluate other methods by which refined sugar quality could be improved.

The main areas of concern regarding refined sugar were turbidity, colour and residual sulphur dioxide.

Turbidity is caused by the suspension of impurity particles greater than 0,1 micron in size in liquor (Bennet, 1974). The composition of the particles covers a wide range of organic and inorganic materials and includes some colloidal impurities (Bennet, 1990). Carbonation is highly effective and can remove up to 99% (Bennet, 1974) of the turbidity in melt. A systematic study was done in the ML refinery to identify possible sources of material contributing to turbidity in the refined sugar produced.

Another area of concern was the high colour of the refined sugar produced at ML. Under South African conditions, refined sugar colour appears to be controlled almost entirely by feed liquor

colour and crystal size (Lionnet and Moodley, 1996). Since the crystal size cannot be changed, due to market requirements, a reduction in sugar colour can only be achieved by reducing that of the feed liquor.

During the past 10 years, the SMRI has done a large amount of work on refinery decolourisation. Preliminary laboratory tests have shown that hydrogen peroxide can be used successfully to decolourise refinery melt (Moodley, 1992). Full scale tests done by the SMRI at a number of refineries have shown that cationic flocculants can remove between 25 and 35% of the colour in the liquor stream (Moodley, 1993). Encouraging results were obtained from laboratory ozone decolourisation tests (Davis, 1996).

In the short term, it was decided to use chemical methods (flocculants, O₃ and H₂O₂) at ML refinery to improve the overall decolourisation of the liquor and, in the long term, to investigate other technologies (activated carbon, ion exclusion and ion exchange).

The work done to reduce residual sulphur dioxide in refined sugar has been described by Moodley *et al.* (1997).

Results and discussion

pH control in the refinery

The pH values at the saturator outlets were too high. It is recommended (Runggas, 1978) that, in multiple saturator stations, a drop to pH 9,3 should be achieved in the first vessels, and the pH leaving the final saturator should be between 8,0 and 8,5. The results of a refinery pH survey done by the SMRI (Table 1) indicated that the amount of carbon dioxide supplied by the boilers at Malelane was insufficient, and the fine liquor pH was too low. This indicated that the fine liquor was being over sulphited.

Table 1
Results of pH survey.

Stream	pH at 25°C				Average
1st saturator outlet A1	10,0	10,6	10,8	10,1	10,4
1st saturator outlet A2	10,0	10,3	10,8	–	10,4
2nd saturator outlet B	9,2	9,8	9,9	9,2	9,5
Carbonated liquor	9,0	9,0	9,6	8,7	9,1
Fine liquor	6,4	6,6	6,4	6,8	6,6

The survey also showed that the colour removal across carbonation was too low (30%), probably due to poor pH control. To improve pH control in the refinery, the following processes were implemented:

- The pH control philosophy was changed and a more sophisticated cascade control loop, incorporating gas flow and liquor pH, was installed.
- Flue gas with a higher CO₂ content was extracted from a bagasse fired boiler during the season.
- The use of better quality coal (B/C-grade to A-grade) improved the CO₂ content of the flue gas during off-crop refining.
- The sulphur burner was replaced with a liquid sulphur dioxide system.
- The pH measuring system was improved by installing better quality pH probes.

After the above modifications were implemented, pH control in the refinery improved dramatically. The decolourisation achieved at the carbonation station increased from 30 to 45%.

Refined sugar turbidity

Refined sugar turbidity as analysed by the SMRI for the 1994 season is shown in Figure 1.

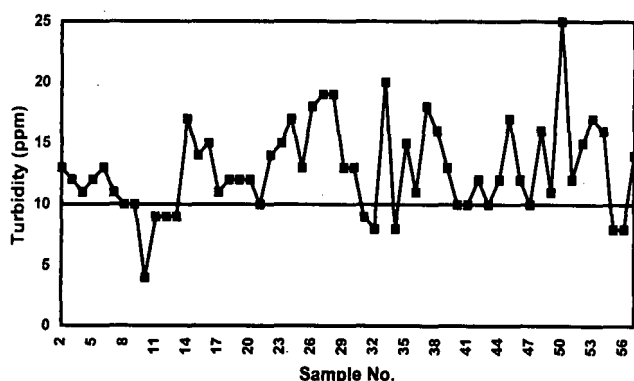


Figure 1. Refined sugar turbidity for the 1994 season.

Results indicated that turbidity was above specification (i.e. >10 ppm) for most of the 1994 season. Analysis of a refined sugar sample showed the presence of the following:

- bagacillo
- black/brown particles
- calcium (probably calcium sulphate precipitate).

To prevent contamination of sugar by air-borne particles, covers were installed on the white sugar conveyors in the refinery. The sulphited filter operation was optimised so that minimum leakage of suspended matter into the liquor occurred. Operator training programmes were also initiated.

Further investigation revealed that refinery sweet water, which was being used as movement water in the refined sugar pans, contained a high level of suspended solids (103 ppm) which contributed to refined sugar turbidity. It was decided to use condensate in the refined sugar pans. Excess refinery sweet water

was then used as melting medium in the raw house melter. The change-over from sweet water to condensate took place at week week 8. The results (Figure 2) indicated a significant improvement in refined sugar turbidity when sweet water was replaced with condensate in the pans. During the 1996 season, refined sugar turbidity was consistently within specification.

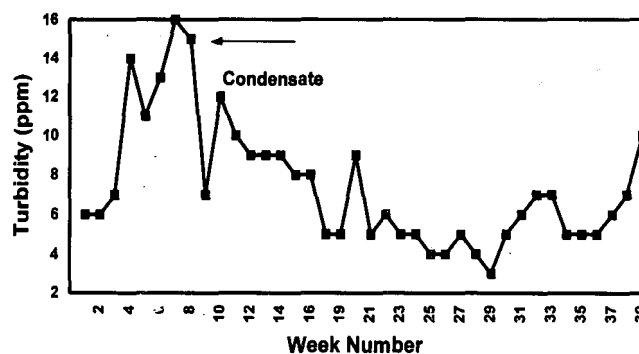


Figure 2. Refined sugar turbidity for the 1995 season.

Refined sugar colour

Average refined sugar colour for the 1989-90 to 1993-94 seasons was 67. This showed that the colour of the refined sugar produced by the ML refinery was above the export sugar specification, which is 45 ICUMSA colour units. The melt and the liquor colours had therefore to be improved before satisfactory refined sugar colour could be achieved.

Melt colour

Refined sugar colour depends on the input melt colour. As ML is a back-end refinery, the colour of the sugar from the raw house can be controlled to a certain degree. Without unduly affecting performance, it was decided that the colour of the melt from the raw house should not exceed 1 200 ICUMSA units. In producing this sugar colour, the raw house achieved 64% A-masseccite exhaustion (industry average = 63,3%). In an attempt to increase the decolourisation levels, it was decided to try to decolourise melt.

Melt decolourisation

Tests were done on melts of three different colours to improve the colour by the addition of cationic flocculants. High levels of decolourisation were achieved with the addition of the flocculants (Figure 3).

The encouraging results obtained in the laboratory led to full scale tests in the refinery. The flocculant was added to melt prior to liming. The average results are given in Table 2. With the addition of flocculant, the melt colour improved by 54% but the fine liquor colour improved only slightly.

Because of the poor results obtained from the full scale tests, further tests were carried out in the laboratory, with factory conditions being simulated. The flocculant was added to melt and lime was then added to various pH values. Results are given in Table 3. At high pH values (>8,8) the results seem to indicate

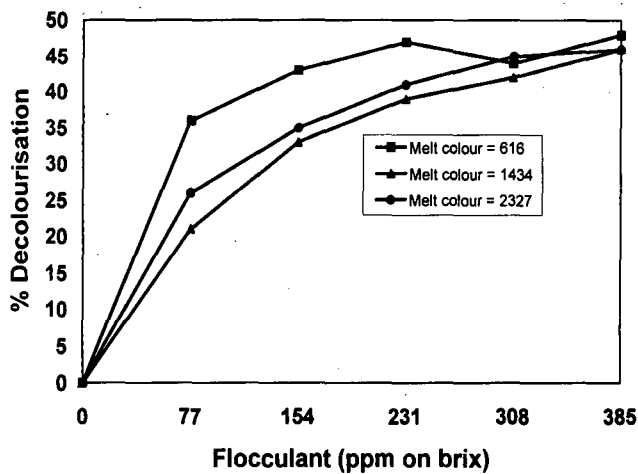


Figure 3. Decolourisation of melt of three different colours.

Table 2
Results of melt decolourisation with flocculant.

Stream	No flocculant	With flocculant	No flocculant
Melt	1 326	609	1 271
Clear liquor	638	578	865
Fine liquor	553	551	663

Table 3
Effect of pH on melt decolourisation.

Sample	Final pH	Colour	% decolourisation
Untreated melt	-	1 067	-
Treated melt	7,0	671	37
	8,8	601	43
	9,5	706	34
	10,5	974	8

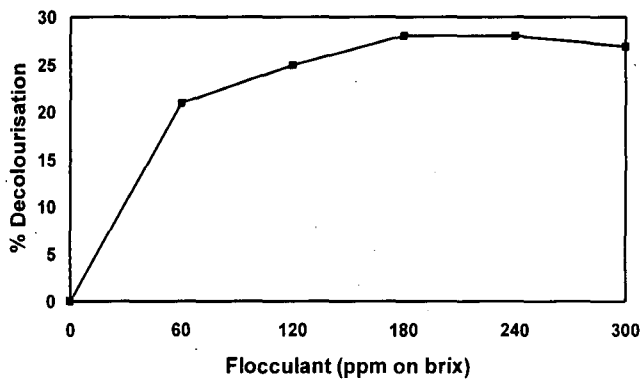


Figure 4. Decolourisation of unfiltered carbonated liquor.

that the colour-flocculant complex is destabilised and the colour goes back into solution. This was supported by the manufacturer's specifications that the flocculant is unstable at high pH. Discussions were held with the supplier to develop a flocculant that would be stable at high pH; the recommended flocculant will be evaluated in the coming season.

Unfiltered carbonated liquor decolourisation

It was further decided to decolourise unfiltered carbonated liquor, which has a pH value of 8,5. The laboratory decolourisation test results in Figure 4 indicated an optimum flocculant dosage of between 100 and 200 ppm on liquor. At these levels liquor colour improved by 25 to 30%.

These laboratory findings have been confirmed in the plant. Flocculant has been dosed at a concentration of 85 ppm (on refined sugar) throughout the past two seasons. Daily colour results for a two month period for B-saturator liquor (no flocculant) and clear liquor (with flocculant) are shown in Figure 5. Average melt, B-saturator and clear liquor colours for this period were 1 252, 685 and 517 respectively. Results confirm that 45% colour removal is achieved over carbonatation and that flocculant removes about 25% of colour in the B-saturator liquor. The addition of the flocculant has increased the decolourisation over carbonatation from 45 to 59%.

Fifth massecuite boilings

Samples of chemically treated (sulphitation, activated carbon and enzymes) jet 4 were boiled in the SMRI pan (Davis, 1995). The feed and affinated crystal colours are plotted in Figure 6.

The results indicate that low crystal colour sugar can be boiled from refinery jet 4. The relationship between crystal (affinated) and jet 4 colour is:

$$\text{Crystal colour} = 10,55 + 0,01417 \times \text{jet 4 colour} \quad (1)$$

(n=6, r=0,91)

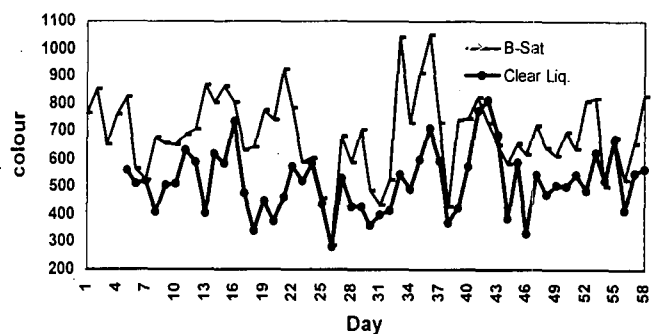


Figure 5. Results from full scale flocculant tests.

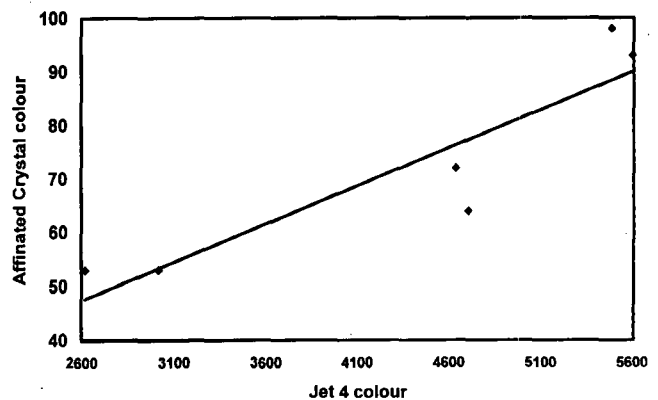


Figure 6. Jet 4 colour versus affinated crystal colour.

Due to the improvement of the fine liquor colour in the refinery, the jet 4 colour also improved. The average jet 4 colour for the season was 4 500. Sugar boiled from jet 4 at this level would produce crystal colour of around 74 (equation 1) and whole sugar (crystal % total sugar = 80%) colour would be about 95. It was therefore decided to boil a fifth massecuite in the refinery.

The preliminary fifth massecuite boiling results were very encouraging, with sugar colour variations of between 80 and 115. Due to this low colour, it was decided to combine this sugar with the other refined sugars. The addition of the fifth sugar would increase the colour of the final product by about 7%. Average results of two refinery surveys done by the SMRI are given in Table 4. During this period the refinery was boiling five massecuites. The decolourisation over carbonatation was about 58%. Even with the addition of the fifth sugar, the final refined sugar was within specification. Plans are in place to make the boiling of the fifth sugar in the refinery a permanent installation. Boiling five massecuites in the refinery offers the following advantages:

- reduced recirculation of liquor and hence a reduction in sugar losses
- a reduction in energy consumption in the refinery
- a marginal increase in raw house and refinery capacity.

Table 4
Refinery surveys.

Stream	Colour
Melt	1 340
Clear liquor	580
Fine liquor	560
First sugar	26
Second sugar	39
Third sugar	67
Fourth sugar	84
Fifth sugar	100
Refined sugar	43
Jet 4	3 630

Overall effects on refined sugar colour

The weekly refined sugar colours as analysed by the SMRI for the 1996 season are given in Figure 7. Sugar colour was below 45 for most of the 1996 season except for four weeks.

Refined sugar colour for the past eight years is plotted in Figure 8. The results show a significant improvement over the past three seasons.

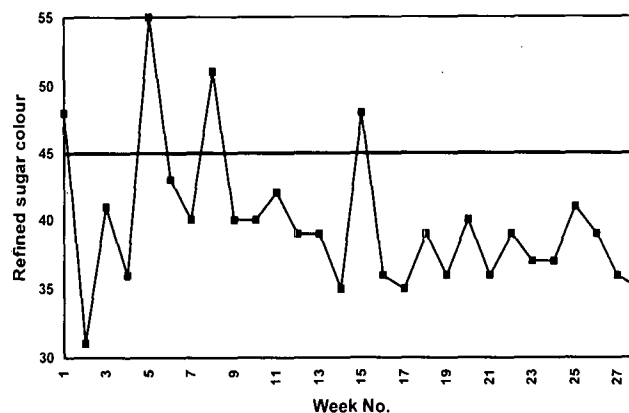


Figure 7. Weekly colour results for refined sugar for the 1996 season.

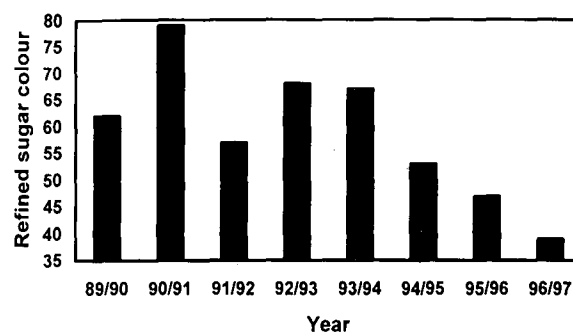


Figure 8. Refined sugar colour for the past eight seasons.

Conclusions

Full scale tests have shown that the suspended matter present in refinery sweet water was contributing to the turbidity in refined sugar. The replacement of sweet water with condensate reduced turbidity.

The following steps were implemented to improve refined sugar colour at the ML refinery:

- improved pH control at both the carbonatation and sulphitation stations
- control of input melt colour
- the addition of decolourising chemicals.

The cost of improving the pH control system at the carbonatation station was about R51 000. The installation of the liquid sulphur dioxide system was about R41 000. The cost of the flocculant dosing pump was R10 000 and the cost of dosing flocculant is 51 cents per ton of refined sugar.

The drive to improve refined sugar quality involved the combined effort of several departments at TSB. What has emerged from this endeavour is that product quality is the responsibility of all plant personnel. The refined sugar currently produced by TSB meets specifications for the domestic, industrial and export markets.

The following projects will be undertaken in the coming season:

- full scale decolourisation of melt with ozone
- pilot plant tests with activated carbon
- boiling of five massecuites in the refinery.

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