

# SOME NOTES ON ABNORMAL PROCESSING DIFFICULTIES DURING SPRING

By <sup>1</sup>K. C. KOSTER, <sup>2</sup>P. L. M. VERMEULEN, <sup>3</sup>M. A. GETAZ and <sup>4</sup>G. R. E. LIONNET

<sup>1</sup>CG Smith Sugar Ltd, Technical Services, Durban

<sup>2</sup>CG Smith Sugar Ltd, Illovo

<sup>3</sup>CG Smith Sugar Ltd, Noodsberg

<sup>4</sup>Sugar Milling Research Institute, Durban

## Abstract

Following 1991's spring rains, unusually severe processing difficulties were experienced at a number of factories over a period lasting several weeks. These problems were especially pronounced at CG Smith Ltd's Illovo and Noodsberg mills where it became almost impossible to achieve reasonable exhaustion of molasses and resulted in unacceptably high target purity differences and recovery losses. This paper documents the experiences at these factories, discusses possible causes for the problems and describes actions taken. An estimate of financial implications is given.

## Introduction

The occurrence of poor crystal growth and low exhaustion after spring rains is not new, being experienced almost every season and usually attributed to increased viscosities in the boiling house. This, often in combination with a seasonally dropping Reducing Sugar:Ash ratio produces a step change in molasses purity and recovery drop-offs not commensurate with the slightly lower mixed juice purity being obtained.

The intensity of the problem at some South Coast and Midland mills in the 91/92 season, however, was such that molasses purities rose to levels not seen for decades and weekly composite target purity differences (TPDs) of up to 18 units were obtained at Noodsberg. This was largely the result of not being able to adhere to the desired pan boiling brix profiles, very slow and irregular crystal formation and problems with massecuite flow, all associated with high viscosity. At Illovo, poor juice clarification and high colour accompanied the pan boiling difficulties.

Noodsberg, Illovo, Sezela and Umzimkulu suffered poor exhaustion during the affected period, in which about R1 300 000 is estimated to have been lost in sugar revenue. The experiences at the two most affected factories, Illovo and Noodsberg, are presented here.

## Description of factory problems

### *Noodsberg*

The problems during the 1991/92 milling season at Noodsberg are the worst on record for this factory. Shortly after the first spring rains in September, a substantial drop in the exhaustion of all massecuites began and continued throughout the month of October, reaching an all time low in mid-November, after which significant improvements in the 'processability' of the cane were seen.

Noodsberg's boiling house problems seem to have gone through two distinct phases. In the initial phase (mid-September to mid-October), the most striking feature was the extreme elongation of the crystals in all strikes. From mid-October onwards, however, the degree of crystal elongation eased slightly but viscosities of massecuites and molasses increased to a virtually unmanageable level. During this

period the C-massecuite formed channels in the crystallisers, did not mix or flow, and wrapped itself around the stirrer elements like toffee. Final molasses would not flow out of the centrifugals unless it was diluted. At the height of the problem, for a period of about two days, the A-pans boiled so slowly that it was suspected that fouling of the tubes was occurring. The pans were inspected during the next stop day but no evidence of fouling was found. Massecuite boiling profiles were compromised due to a persistent full back-end situation in which pans were constantly waiting to strike, or were deliberately struck slack in order to try to ensure that the massecuite would flow through the crystallisers. B- and C-pans at Noodsberg are fitted with stirrers and, as a normal operational procedure, final brixing continues until the stirrer trips out. At times this was happening even before brixing-up began or when the pan was half-full. Final massecuite brixes during this period therefore dropped substantially and molasses purities climbed.

Final molasses TPD rose from +3,4 in week 21 (mid-September) to an average of +10 for the remaining nine weeks of the season, reaching +18 for the final two weeks. During this problem period, sucrose and purity of the incoming cane declined steadily, but not excessively, while a dramatic increase was observed in the cane's ethanol content. This averaged 5 250 ppm (on brix) in August, 6 250 ppm in September, 8 800 ppm in October, and 7 500 ppm in November.

### *Illovo*

At Illovo, the factory's processing crisis began in the second week of October after 86 mm of rain and 45 hours of no-cane stops. The factory suffered difficulties which in many ways were similar to those at Noodsberg although losses were not as severe. This may have been due to a milder change in the cane's characteristics, or to remedial action taken in the factory during the period.

The ethanol content of cane rose from an average of 4 100 ppm on brix to over 7 000 ppm on brix, and remained at this level for the next seven weeks as wet conditions continued in the fields and burn to crush time remained excessive. Individual consignments with up to 23 000 ppm ethanol were measured. Mixed juice purity dropped by 1 unit immediately, but at 87, would still be considered high, and glucose and fructose levels gave no indication that abnormal inversion had taken place in the cane. The Reducing Sugar:Ash ratio in juice reached its lowest point in the week when the difficulties began.

An unusual feature was the low level of phosphate measured in mixed juice during the period. This dropped from 170 ppm ( $P_2O_5$ ) to an average of 138 ppm for the remainder of the season and levels as low as 100 ppm were determined.

• **Sugar quality.** Sugar produced during the period and tested by the SA Sugar Terminals was found to have 850 ppm dextran (Roberts method) against an earlier season av-

erage of 250 ppm. According to Legendre (1991), this would imply approximately 4 000 ppm dextran on solids in mixed juice, a level which could account for the gumminess experienced. The presence of such elevated dextran levels is also consistent with the cane's deterioration after long burn to crush delays.

- **Clarification.** Clarified juice turbidity increased progressively during October despite changes to flocculant dosage and could only be brought under control by adjusting the phosphate levels in mixed juice to 170 ppm with the addition of phosphoric acid. This step eliminated clarifier carryover and may have played a part in reducing downstream viscosity.
- **Pan Boiling.** In the boiling house, high viscosity was a problem throughout the period, causing boiling times to be extended in attempting to arrive at an acceptable C-masseccuite striking brix.

Despite increases in the A-molasses graining charge and raising C-masseccuite purity from 52,5 to 55, the average C-masseccuite brix dropped from 97,5 to 96,5 and crystal size decreased from 140 micron to 100 micron in width. No improvement in crystal size was obtained by varying the slurry charge and very pronounced crystal elongation was in evidence, SMRI reporting a 2,5:1 length to width ratio.

Exhaustions of A-, B-, and C-masseccuites dropped off and final molasses purity rose steadily over the next five weeks, with TPD peaking at +7,4 units before improving.

Other steps taken to control the situation which are believed to have been helpful were:

- The increased dosage of sodium hydrosulphite from 160 ppm to 400 ppm on masseccuite into the C-pans. This was seen to be effective in containing masseccuite viscosity and relieved some of the pressure on the pan floor.
- The increased use of final molasses lubrication to facilitate C-masseccuite flow across the crystallizers.
- The reduction in non-sucrose recirculation by the curing of higher purity C-sugar.

### Investigations

#### The influence of weather

Rainfall statistics for the Cramond, Jaagbaan and Seven Oaks area which supplies most of Noodsberg's cane show an unusually wet spring with a total rainfall of 375 mm versus the 20 year mean of 202 mm for the three month period (see Figure 1). The falls were fairly evenly distributed with rain on 57 days out of a possible 91. These conditions produced prolonged periods during which vehicles could not enter the fields and resulted in cane deteriorating during the long burn to crush times. A similar, but slightly lower rainfall pattern, was recorded at Richmond and Illovo. This could explain why high dextran levels and viscosities were very pronounced at Noodsberg and Illovo which are fed 100% and 80% respectively by Midlands cane. The areas from Stanger northwards which were little affected by exhaustion difficulties, experienced much drier weather.

#### Viscosity measurements at SMRI

In order to try to characterise the problematic element at Noodsberg, catch samples of syrup and A-, B-, and C-molasses taken at the height of the gummy period were sent to SMRI for viscosity measurements.

Viscosities were measured using a Brookfield viscometer with spindle T2, at actual sample brix and at 30°C.

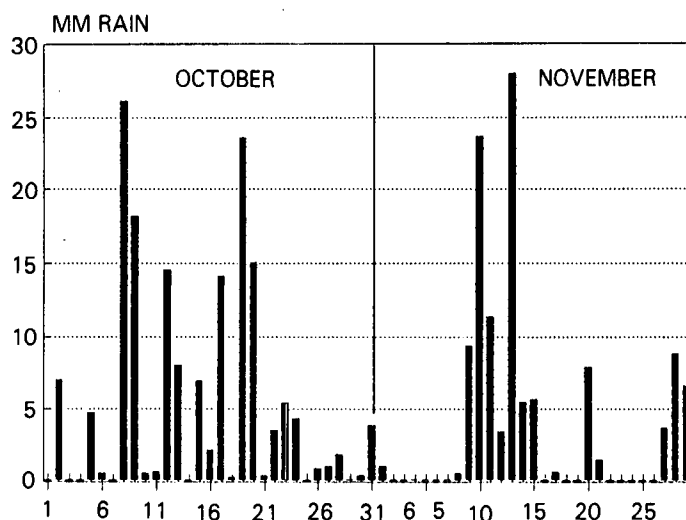


FIGURE 1 Rain fall in October and November at Crammond, Seven Oaks and Jaagbaan

Using previously established relationships between molasses brix and consistency (Lionnet, 1991), it was possible to estimate the consistency of final molasses samples from Malelane, Gledhow, and Sezela at the same brix as the Noodsberg samples. These calculated consistencies were used for comparison purposes. Measurements on catch samples showed Noodsberg molasses to be at an almost unheard of level of 270 Pa.s – six times more 'viscous' than final molasses from Sezela and 45 times more 'viscous' than Malelane's for the same brix and temperature (see Table 1).

Table 1

Viscosity of Noodsberg samples (30°C and actual brix) (Calculated values for molasses from Malelane, Gledhow and Sezela also given)

| Product    | Brix | Viscosity (Pa.s) | Calculated viscosity (Pa.s) |    |    |
|------------|------|------------------|-----------------------------|----|----|
|            |      |                  | ML                          | GH | SZ |
| Syrup      | 61,5 | 0,2              | -                           | -  | -  |
| A-molasses | 77,0 | 2                | -                           | -  | -  |
| B-molasses | 76,9 | 26               | 1                           | 6  | 17 |
| C-molasses | 81,6 | 270              | 6                           | 24 | 45 |

#### Variation in molasses viscosity

The routine weekly final molasses samples for Illovo and Noodsberg, retained at the SMRI laboratory, were then used to measure the flow behaviour index (n) and the consistency (K) over a 22 week period from 15 June 1991 to 30 November 1991.

The following observations were made from these results:

- Viscosity started increasing shortly after the spring rains at the beginning of October in Noodsberg, to reach values 2-3 times higher than the average prior to October.
- Viscosity started increasing in mid-October at Illovo, to reach values 1,5-2 times higher than the average of the previous weeks.
- The viscosity peaked at the same time, namely during the first two weeks of November, at the two factories. The trends with time are also similar.
- The flow behaviour indices and the trends with time at Noodsberg and Illovo are similar. It appears that the consistency and the flow behaviour index are inversely related.

- TPD at both Illovo and Noodsberg increased proportionately with the viscosity rise and improved as viscosity dropped (see Figures 2 and 3).

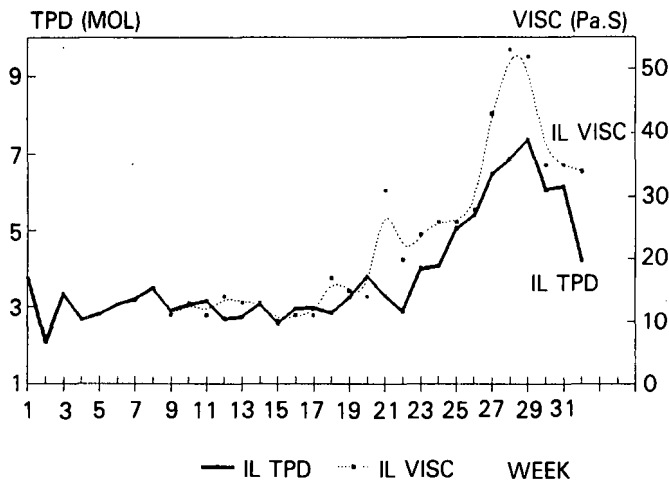


FIGURE 2 TPD versus viscosity at Illovo

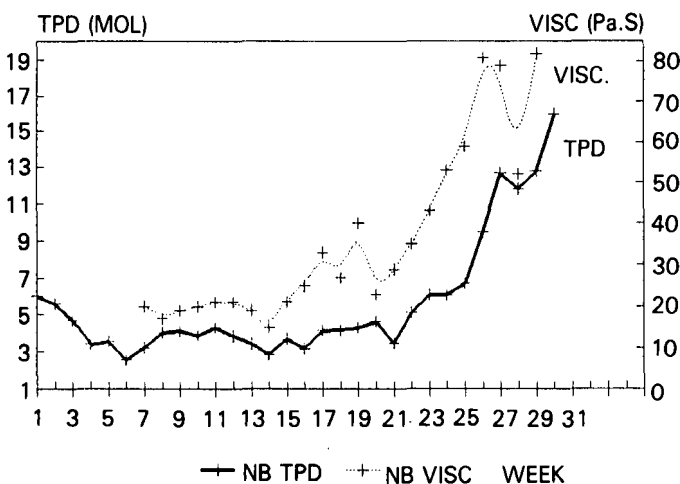


FIGURE 3 TPD versus viscosity at Noodsberg

**Preliminary work on the effects of dextranase and sodium hydrosulphite on the viscosity of molasses**

A preliminary assessment of two possible agents which could be used for reduction of high viscosity was carried out at the SMRI. In this investigation (Lionnet, 1992), various Noodsberg molasses samples were used to test the effects of dextranase and sodium hydrosulphite (blankite) on viscosity.

The molasses samples were diluted to 74° brix and split 3 ways. The first sub-sample was used as a control. Dextranase was added (400 ppm on sample) to the second sub-sample, at 60°C, and the molasses was kept at 60°C for two hours. The third sub-sample was treated with either 500 ppm or 2 000 ppm sodium hydrosulphite and also kept at 60°C for two hours. Flow behaviour indices and consistencies were then measured. The results are reported in Table 2.

In all cases, the addition of dextranase or sodium hydrosulphite reduced viscosity, confirming the practical improvements observed after sodium hydrosulphite was used at Illovo. No attempt whatsoever was made to optimise the effect or to establish whether the use of these chemicals is financially viable.

**Estimation of losses**

An estimate of financial losses at the factories was made by assuming that all weekly molasses samples from the affected period with higher than +4,5 TPD had incurred abnormal molasses loss.

The sugar loss attributable to the difference in purity in excess of +4,5 TPD was then calculated for each of these weeks by the following formula:

$$\text{Sugar loss} = (\text{SJM actual} - \text{SJM at 4.5tpd}) * \text{tons suc MJ} / 99,5$$

For every ton of sucrose calculated to have been lost to molasses, a ton of additional molasses was deemed to have been made and its value allowed for in the financial estimate.

Losses incurred by Illovo, Noodsberg, Sezela, and Umzimkulu (Refer Table 4):

|      |                    |         |               |
|------|--------------------|---------|---------------|
|      | 1686 tons sugar    | @ R 900 | = R 1 517 000 |
| less | 1678 tons molasses | @ R 104 | = R 175 000   |
|      |                    |         | R 1 342 000   |

Table 2

Flow behaviour index (n) and consistency (K) (Pa.s) at 74° brix and 25°C of molasses treated with dextranase or sodium hydrosulphite

|            | No Treatment |      | Dextranase (400 ppm) |      |        | Blankite (500/2 000* ppm) |     |        |
|------------|--------------|------|----------------------|------|--------|---------------------------|-----|--------|
|            | n            | K    | n                    | K    | % drop | n                         | K   | % drop |
| A-molasses | 0,95         | 2,4  | 0,87                 | 2,7  | -      | 0,82                      | 2,8 | 20     |
|            | 0,80         | 3,5  | 0,96                 | 2,0  | 43     |                           |     |        |
|            | 0,73         | 4,3  | 0,81                 | 2,4  | 44     |                           |     |        |
|            | 0,93         | 3,2  | 1,0                  | 2,5  | 22     |                           |     |        |
|            | 0,98         | 1,9  | 0,97                 | 1,6  | 16     |                           |     |        |
| B-molasses | 0,62         | 8,5  | 0,82                 | 1,9  | 78     | 0,79                      | 2,2 | 39     |
|            | 0,66         | 3,6  | 0,88                 | 1,1  | 69     |                           |     |        |
|            | 0,66         | 5,2  | 0,90                 | 1,7  | 67     |                           |     |        |
|            | 0,56         | 29,8 | 0,63                 | 24,4 | 18     |                           |     |        |
|            | 0,67         | 6,1  | 0,92                 | 2,1  | 66     |                           |     |        |
| C-molasses | 0,89         | 14,4 | 0,72                 | 8,0  | 44     | 0,72                      | 8,8 | 44     |
|            | 0,66         | 15,8 | 0,60                 | 10,7 | 32     |                           |     |        |
|            | 0,60         | 11,1 | 0,64                 | 8,8  | 21     |                           |     |        |
|            | 0,68         | 10,2 | 0,74                 | 4,7  | 53     |                           |     |        |

### Conclusions

The exhaustion fall off which occurred in spring 1991 was the worst on record, resulting in big recovery losses to the CG Smith Sugar group of factories. While the problems may, on this occasion, have been accentuated by almost freak weather conditions, they are well enough known in a milder form and must have cost the sugar industry enormous sums over the years. It is important that every effort be made to identify and prevent, or at least minimise, these losses when similar conditions arise in the future.

To this end, the following points are offered:

- The factory problems are due to a change in the properties of the cane being crushed. The change in cane could be physiological, as in regrowth after rain, but is more likely the result of deterioration after cutting or burning. This appears to be indicated by the high ethanol levels found at Illovo and Noodsberg and by the high dextran content of Illovo's sugar. Confirmation of the cause needs to be established.
- Ideally, the problem should be addressed at the source. Burn to crush times must be more strictly monitored and all harvested cane should be crushed as soon as possible.
- An early warning indicator is needed for the factory. The normal cane quality parameters; sucrose, purity, reducing sugars, fibre content, etc., appear to be of no value for this purpose. Ethanol content, if determined routinely and representatively is likely to be useful. The regular measurement of polysaccharides in juice should also be investigated.

- The correlation between high viscosity and high TPD was very marked at Noodsberg and Illovo. More research needs to be done to confirm that this is the case at other factories and to provide a better understanding of the components that cause viscosity.
- Last season's experience at Illovo has shown that some success could be obtained by treating massecuite with sodium hydrosulphite to improve handling characteristics. The use of this or other viscosity reducing aids and chemicals such as phosphoric acid to improve clarification appear to be viable options for Process Managers once the cane has been crushed.
- The effectiveness of sodium hydrosulphite was confirmed in limited tests at SMRI as was the use of dextranase. Further tests and optimisations will have to be done in the near future.

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