EXPERIENCES WITH PROCESSING VERY LOW PURITY CANE

J BECKETT AND SS MUNSAMY

CG Smith Sugar Limited, Sezela

Abstract

The two year drought on the South coast (1992 and 1993) resulted in the Sezela Mill processing cane with abnormally low purity. The average mixed juice purity for the 1993 season was 80,4 (sucrose based), and at times the purity dropped to 70. Sezela Mill still managed to produce sugar at 99,45 polarity and 1954 ICUMSA colour units. Some of the process changes that were required to process low purity cane during the drought period are described.

Introduction

The 1992 and 1993 seasons will be regarded as the drought years at Sezela. Some of the challenges that the Process department faced were:

- Processing of poor quality cane
- Shortage of water
- The temporary closure of Umzimkulu and Illovo mills resulting in a number of changes.
  - i) Sezela had to produce sugar to prepack quality standards.
  - ii) Sezela supplied Illovo Mill with sugar to produce syrups.
  - iii) Part of the production was prepacked at Sezela and part at Umzimkulu.

This paper looks at the following:

- The effect of cane purity on performance and throughputs.
- The effect of some of the operating changes on performance.

Cane crushing strategy

Cane quality parameters are shown in Table 1 for the last six years at Sezela.

Table 1
Cane and sugar quality at Sezela over the last six seasons

Parameter	1988	1989	1990	1991	1992	1993
Sucrose % cane	12,5	12,6	12,7	12,7	13,9	12,1
Fibre % cane	16,2	16,6	16,4	16,1	17,5	18,8
Brix % cane	15,0	15,0	15,1	15,2	17,5	15,4
Moisture % cane	68,9	68,5	68,5	68,9	65,4	65,8
Mixed juice sucrose purity	84,9	84,8	85,6	85,0	80,8	80,4
Clear juice colour	20 700	24 900	23 600	25 100	27 200	34 900
Sugar pol	99,46	99,46	99,50	99,44	99,41	99,45
Grain size (mm)	0,64	0,61	0,57	0,62	0,59	0,64
Colour (ICUMSA)	1 295	1 425	1 412	1 627	1 620	1 954

The drought had a dramatic effect on the cane quality. The comparison between the drought period and previous seasons shows:

- Moisture percent cane was lower by about 4%
- Brix percent cane in 1992 was 13% higher
- Mixed juice purity was lower by about 4 units
- Juice colour was abnormally high.

It was recognised that the high impurity levels in drought cane, together with the associated effects of poor cane quality, would determine the cane crush rates. A theoretical model was developed based on the 1988 figures for week 15, where the hourly rate of 497 tons per hour exceeded the design parameter of 450.

The figures were:
Non-pol rate = 10,8 tons/hour
Mixed juice brix = 12,0
Mixed juice % cane figure of 136% was used which is a typical operating parameter for Sezela.
Average number of hours crush per week = 160

Table 2 shows theoretical crush rates at different juice purities.

Table 2
Calculated maximum crush rates for different mixed juice purities

Juice purity (pol)	Cane crush rates	
	Tons/hour	Tons/week
85	440	70 400
83	390	62 400
81	350	56 000
79	315	50 400
77	290	46 400

It is a useful guide when wide variation in cane quality is experienced, which was the case in the 1992 and 1993 seasons. In the event that the non-pol rate exceeded 10,8 tons/hour sacrifices had to be made to sucrose recovery to accommodate the excessive loading.

Changes to normal operating conditions

Clarification

During the latter half of the 1992 and 1993 seasons, clarification difficulties were experienced as a result of the low phosphate level in the mixed juice. The juice was dosed continuously with phosphoric acid to a phosphate level which gave an acceptable clear juice quality and mud consistency, rather than aiming for the theoretical level of about 300 ppm as quoted in the literature (Anon., 1985). It was noted that a phosphate content of about 180 ppm was required for satisfactory clarification. Phosphoric acid to the value of R17 000 and R98 000 was used in 1992 and 1993 respectively.

Pan boiling

At times the high brix loading together with the low purities, required that the pans be boiled for a fixed time period rather than aiming for a high brix. This time period was based on the time it took to fill the pan to maximum capacity under normal conditions.

- To assist in reducing the boiling times, the steam supply to the 85 m^3 B-massecuite pan and the continuous C-pans was changed to a higher grade vapour, i.e. from V2 to V1.
- To avoid fluctuations in the V1 vapour pressure, exhaust steam was let down into the V1 main to keep the V1 pressure between 45 and 50 kPa.
- The low A-molasses purities (1993 season average of 62,6) required that the B- and C-seed be grained on syrup or a syrup and molasses blend.

Crystallisers

The A- and B-crystalliser stations consist of two streams operating in parallel. The A-crystalliser station has 16 horizontal crystallisers (45 m^3 each) with eight crystallisers per stream operating in series, and the B-station has eight vertical crystallisers (56 m^3 each) with four crystallisers per stream operating in series.

The following changes were made in the 1992 and 1993 seasons.

- 50% of the A- and B-crystallisers were bypassed.
- In the operating streams the last two A-crystallisers and the last B-crystalliser were changed from a cooling to a reheating duty.
- No cooling water was used on the A-crystallisers.

Centrifugal station

A model was developed outlining the effect that massecuite purity has on A-centrifugal capacity. This relationship is shown in Table 3.

Table 3
Relationship between A-massecuite purity and centrifugal capacity

A-massecuite purity	Molasses purity	Crystal content (%)	Molasses content (%)	Molasses loading (kg/cycle)	Centrifugal capacity (kg/cycle)
86	64	57	43	538	1 250
84	62	54	46	538	1 170
82	62	49	51	538	1 055
80	62	44	56	538	961
78	62	39	61	538	882

The model was based on typical operating conditions at Sezela. The A-centrifugals have a maximum rated capacity of 1 250 kg/cycle and experience has shown that this can be achieved at about 86 purity. At this purity the molasses loading on the centrifugal was about 538 kg/cycle.

Crystal content was calculated using the formula:

$$\text{Crystal content} = \frac{(\text{Massecuite purity} - \text{Molasses purity}) \times \text{Massecuite brix}}{(100 - \text{Molasses Purity})}$$

A massecuite brix of 93° was used for the calculation. For a large part of the 1992 and 1993 seasons the A-centrifugals were charged to about 75% of the rated capacity to achieve acceptable sugar quality. During the latter half of the 1993 season, the top speed on all the A-centrifugals was reduced from 1300 rpm to 1000 rpm. This was as a result of severe centrifugal vibration caused by problems associated with molasses purging. This caused extensive damage to the machines and as a consequence the maintenance cost for 1992 and 1993 was 120% higher than the normal season cost of R42 300. The centrifugals were also run on very long cycle times to achieve acceptable sugar quality.

Effect of brix on viscosity

Sezela's final molasses viscosity has generally been higher than that of other factories. Table 4 shows that final molasses viscosity can be halved by dropping the dry solids content of molasses by about two units. This relationship prompted Process staff to decrease product brixes during periods of high viscosity.

Reheating of C-massecuites

During periods of high viscosity there was a tendency for the C-crystalliser level to increase as a result of poor massecuite flow into the centrifugals. To alleviate this problem, the reheater water temperature was increased to 74°C as opposed to the normal operating temperature of 66°C.

Table 4
Effect of brix on final molasses viscosity

Week ending	Undiluted sample (% dry solids)	Viscosity (Pa.s)	Viscosity (Pa.s) after dilution to 74% dry solids
03-10-92	75,0	24,2	11,3
10-10-92	76,7	34,7	6,5
17-10-93	76,9	32,1	12,6
24-10-93	76,0	26,2	14,4
01-11-93	76,2	22,5	11,2
07-11-93	76,0	20,5	9,8

Results and discussion

Sugar quality

The sugar quality during the drought period, except for colour, compared well with that of previous seasons. The sugar colour was high in 1993. However when one considers the juice colour of 34 900, the sugar colour of 1954 was satisfactory. It should be noted that the dosing of phosphoric acid was not the prime reason for achieving an acceptable sugar quality, because phosphoric acid was only dosed for a small part of the 1992 and 1993 seasons. Sodium hydrosulphite was dosed in the 1992 season but not in the 1993 season.
Sugar quality is shown in Table 1.

Effect of bypassing crystallisers and reheating

- Although the A-massecuite purity during 1988 was four units higher than that during the drought periods, the purity differences across the A-station were similar for the different seasons. The comparative data are shown in Table 5.

Table 5
The effects of bypassing 50% of the A-crystallisers, no water cooling, and reheating of A-massecuites during the 1992 and 1993 seasons

Parameter	1988	1992	1993
Brix loading (tons/hour)	59,40	58,55	48,38
A-massecuite rate (tons/hour)	84,82	82,79	69,08
A-massecuite purity	84,08	81,64	80,92
Bypassing crystallisers (%)	0	50	50
Massecuite temperature (°C)	-	55	55
Purity difference	18,37	18,37	18,28

- The comparative data for the performance across the B-station (Table 6) indicates that the bypassing and reheating of B-massecuite resulted in a decrease in performance of about four purity units.

Table 6
Effects of bypassing B-crystallisers and reheating of the B-massecuite

Parameter	1988	1992	1993
B-massecuite rate (tons/hour)	24,98	26,32	25,25
B-massecuite purity	65,8	65,6	64,8
Bypassing crystallisers (%)	-	50	50
Massecuite temperature (°C)	-	56	56
Purity difference	26,6	22,2	21,0

Reheating of C-massecuites

- The high C-reheater water temperature of 74°C did not result in a marked increase in purity rise across the reheater. The massecuite temperature after reheating was generally around 68-70°C. The reheater water temperature and the purity rise across the reheater are shown in Table 7.

Table 7
Operating conditions across the C-station

Parameter	1988	1989	1990	1991	1992	1993
Massecuite volume (m³/hour)	16,63	13,75	14,10	15,68	22,25	15,96
Molasses quantity @ 85° brix (tons/hour)	15,80	14,81	14,60	14,82	21,20	17,90
Crystalliser rentention time (hours)	42,2	51,1	49,8	44,8	31,6	44,2
Massecuite purity	54,4	51,9	52,4	53,6	57,0	53,3
Reheater water temperature (°C)	-	66	66	68	74	74
Purity difference across reheater	-	0,8	0,2	0,8	0,8	0,8

C-massecuite retention times

Very high volumes of C-massecuite and molasses were processed during the 1992 season. A-molasses was cascaded to the continuous C-pan once the B-pans could not cope with the high volume. The high viscosities and short retention times in the pans and crystallisers required the following.

- The C-seed grain size had to be increased to compensate for the reduction in retention time by increasing the C-massecuite purity.
- The C-massecuite brix was dropped marginally to reduce viscosity.

C-station data are shown in Table 7.

The effect of low brix on A-station performance

During October 1992 (week no. 26) the A-massecuite was very viscous and it was difficult to achieve a brix of 93°. To avoid throughput reduction, the A-pans were boiled for an average time of 3 hours and at a lower brix. The effect of low brix on purity difference (massecuite - molasses) and crystal size is shown in Table 8.

The lower A-massecuite brixes resulted in:

- A drop in exhaustion when comparing purity differences for the respective periods
- A significant drop in the sugar grain size.

Effect of purity on centrifugal capacity

During the period depicted in Table 8, all the A-centrifugals could only be charged to 75% of the rated capacity and at times as low as 50% to obtain the required sugar quality. This operating condition agrees well with that predicted by the model (Table 3), where a purity of 80 units corresponds to a maximum capacity of 961 kg/cycle, i.e. 75% of the rated capacity.

Process performance

The following key performance parameters are evaluated in this section.

- Corrected reduced boiling house recovery (CRB)
- Target purity difference (TPD)
- Undetermined loss (UL)

Table 9 shows that 1992 was a difficult season in terms of CRB and TPD.

Table 8
The effect of a lower A-massecuite brix

October 1992 : Week No. 26

Day No.	A-Massecuite		Purity difference	Sugar grain size
	Brix	Purity		
1	90,90	78,32	16,21	
2	91,30	79,04	16,24	
3	91,17	79,82	16,54	
4	91,33	78,72	15,40	
5	91,10	78,95	16,23	
6	92,49	80,01	17,95	
7	92,76	80,20	16,26	
Average	91,71	79,30	16,37	0,54

September 1993 : Week No. 20

Day No.	A-Massecuite		Purity difference	Sugar grain size
	Brix	Purity		
1	93,79	80,89	19,06	
2	93,85	80,13	18,27	
3	93,88	80,04	19,15	
4	93,88	79,81	16,84	
5	93,52	80,44	19,90	
6	93,81	80,07	21,01	
7	93,57	80,47	18,84	
Average	93,76	80,50	18,43	0,63

Table 9
Performance data for Sezela over a period of five years

Parameter	1989	1990	1991	1992	1993
Mixed juice purity (sucrose)	84,9	85,6	85,0	80,8	80,4
CRB	86,9	87,1	87,3	84,7	86,8
TPD	4,2	4,2	3,9	7,7	4,8
UL	2,2	2,0	1,6	2,5	2,0

The benefits of the changes and staff experience were realised in the 1993 season, where there was a marked improvement in performance when compared with the 1992 season.

- 2,9 unit decrease in TPD
- 0,5 unit decrease in UL
- 2,1 unit increase in CRB

The reducing sugar ash ratios for the two seasons were significantly different, i.e. 1,3 in 1992 and 0,7 in 1993 which may have affected performance.

The 1993 season performance figures compare satisfactorily with those achieved under normal conditions.

General

It is difficult to document all the technical and human resource changes required during the drought years. The effect of some of the technical changes made were difficult to evaluate because conditions were changing rapidly. During the height of the drought, the Process staff had to be flexible in responding to the changing conditions.

It was this approach that enabled Sezela to produce VHP sugar at an acceptable rate and quality. Many of the technical decisions were based on "gut feel" and it is very difficult to put figures to them. The best technical decisions would not have produced good results without the dedication and commitment of the staff. The Sezela Process staff displayed a high degree of motivation and team effort during the difficult conditions. The human resource changes of management style, leadership, staff training and freedom to experiment were the foundations for the technical performance improvement in 1993.

Conclusions

Normal operating procedures in a sugar factory are geared to produce high sucrose recovery. During abnormal conditions a compromise needs to be made between throughput and recovery. The accepted factory sizing parameter of tons cane per hour is inadequate under low juice purities, where non sucrose loading determines factory throughput.

Drought conditions result in the agriculture sector trying to complete the crop over a short season. This puts pressure on the factory to crush at higher rates and consequently the mill is forced into a compromise between throughput and recovery.

The traditional method of high brix and low temperature products in the back-end can be detrimental to throughput and sugar quality. When faced with low juice purities and high throughput requirements, it is recommended that Process staff evaluate the effects that high massecuite brix, low crystalliser temperature, low C-massecuite purity and low vapour pressure have on throughput and recovery.

Sezela mill has shown that small changes to brix and temperature can result in large changes to viscosity which affect throughput and sugar quality.

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