

# THE PRACTICAL DEVELOPMENT AND APPLICATION OF SACCHARATE LIMING AT THE PONGOLA SUGAR MILL

By S. NORTH-COOMBES and K. TAYLOR  
(Smithtech (Pty) Ltd., Durban)

By K. C. KOSTER  
(C.G. Smith Sugar Limited, Pongola)

## Abstract

The practical development of the saccharate liming system installed at the Pongola sugar mill is discussed. The effect of this process, in comparison with the "hot" liming method normally practised throughout the Industry was investigated and it was concluded that it gave a clear juice with a far superior clarity and improved the purity drop across the clarification station.

## Introduction

Good juice clarification undoubtedly plays an important role in the performance achieved in the boiling operations of a factory.

Since the introduction of simple defecation, numerous liming techniques have been developed to try and achieve the best quality clear juice using this process. Saccharate liming is not a new process and has for a number of years been successfully used in mills in Australia (Davis<sup>1</sup>), Reunion and Mauritius<sup>2</sup>.

Towards the end of the 1977-78 season, laboratory trials comparing saccharate liming to the conventional "hot" liming technique normally practised in the industry, were carried out at four mills within the C.G. Smith Group. Results achieved were very encouraging, saccharate limed juices producing a clarified juice of a far lower turbidity together with larger mud volumes. (Appendix 1).

Factory trials commenced at Pongola during the 1978-79 season but were discontinued the following season as a result of unacceptably high filter cake losses. The then filter capacity at Pongola was already marginal for the amount of cane being crushed and together with the additional mud produced by the saccharate liming, led to these high losses (0,43 Pol loss % Pol in MJ).

Following the installation of additional filter capacity, saccharate liming was re-introduced and ran throughout the 1980-81 season, recording good clear juice and "normal" filter cake losses (0,33 Pol loss % Pol in MJ).

## Formation of Lime Saccharates

Although the term "sucrate" officially designates chemical combinations with sucrose, "saccharate" is a term widely known and used in the sugar industry and has been adopted here.

In the reaction between calcium oxide and sucrose (milk-of-lime and sugar solutions), it has been established (Hartmann<sup>3</sup>) that there are three possible structures, viz. mono-, di- and tri- calcium saccharate depending on the chemical and physical conditions under which the reaction is conducted. Of the three, mono-calcium saccharate is the most soluble (especially at low temperatures) which in aqueous

sugar and milk-of-lime solutions exhibits the properties of a true salt.

The probable reaction mechanism for the three saccharates as proposed by Hartmann<sup>3</sup> is shown in Figure 1.

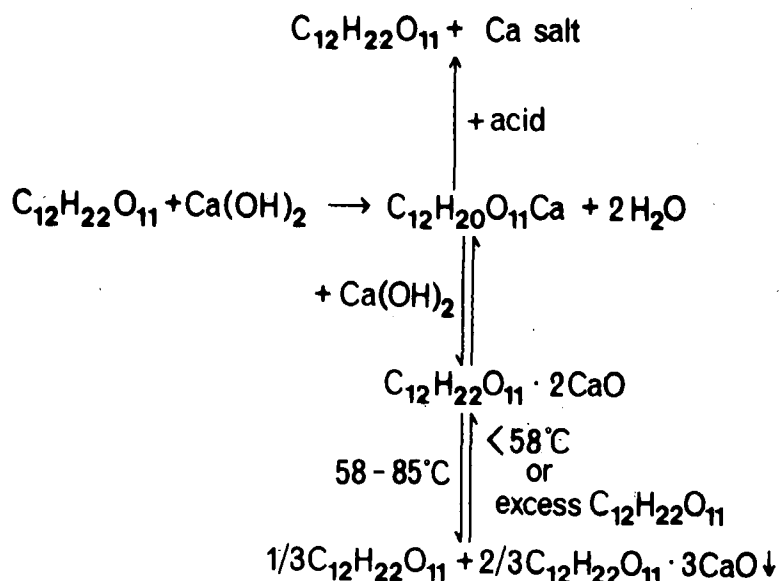


FIGURE 1 Probable Saccharate Reaction Mechanism.

In order to ensure that the highly soluble mono-calcium saccharate is formed, it is important to maintain the following two conditions during preparations :—

- (a) A slight excess of sucrose.
- (b) A temperature below 58°C.

From the stoichiometry a ratio of sucrose to calcium oxide of 6,1:1 is required, in practice a ratio of 7:1 is used thereby maintaining the slight excess of sucrose required.

In a factory there are many sources of sucrose that can be used to produce the required saccharate solution, from filtrate through to syrups.

At Pongola, refinery syrup and clear juice were tried for a short period. The former gave a good clear juice but re-circulated too much fine liquor back to the raw house while the latter produced a poorer clear juice clarity and required a far greater volume of solution to make up the required sucrose to calcium oxide ratio. Evaporator syrup was finally adopted as it gave a good clear juice clarity and required only a small volume for the sucrose level required.

At the 7:1 ratio, using 68° brix evaporator syrup and 15° Bé milk-of-lime, it was found that the pH of the resulting saccharate solution was in the range 11,0 - 11,5. Hence, by controlling the saccharate pH at 11,0 excess sucrose is present and the formation of the mono-calcium saccharate is assured.

### Preparation and Use of Saccharate at Pongola

The fully automated preparation plant adopted is illustrated in Figure 2.

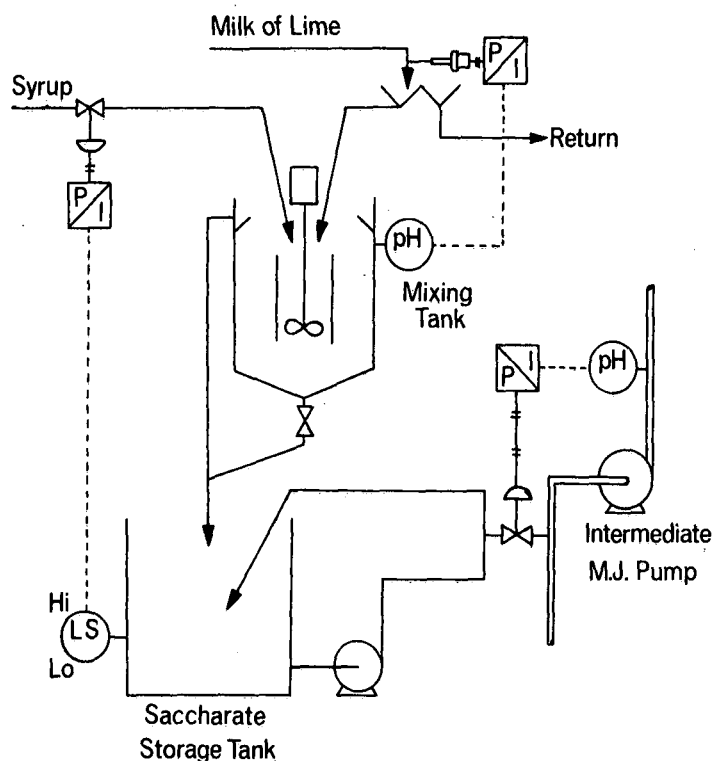


FIGURE 2 Pongola Saccharate preparation and dosing system.

The syrup and milk-of-lime solutions are fed into the mixing tank which is sized for a retention period of 5 minutes (Meade *et al*<sup>4</sup>) to provide sufficient contact time for the saccharate to form. The syrup is fed at a fixed rate into the mixing tank and the milk-of-lime flow addition is controlled by the pH of the saccharate solution, being at a pH of 11,0. The resulting saccharate solution overflows to a storage tank from where it is pumped through a circulating ring main by means of a conventional centrifugal pump. High and low set points in the storage tank actuate the addition of the syrup and, together with the pH controller, the saccharate is automatically made up. Saccharate is dosed from the ring main into the mixed juice line at a point prior to the intermediate juice pump after the primary heating stage. All

excess saccharate returns to the storage tank, where a nozzle fitted to the discharge provides sufficient agitation to the solution in storage.

Experience gained in Australia (Wallace<sup>5</sup>) indicated that saccharate liming should be carried out at the intermediate stage. This point was confirmed when "hot" saccharate liming was attempted at the Gledhow sugar mill, while giving a good clear juice it also produced unacceptably high mud levels in the clarifiers.

There are a number of inherent advantages when pumping, piping and storing calcium saccharate in contrast to the milk-of-lime suspensions, which is difficult to handle even under the most favourable conditions. With saccharate solution centrifugal pumps may be used, pipe blockages are negligible and agitation of storage tanks can be minimal.

An additional advantage that saccharate has over milk-of-lime is that of pH control, resulting in a steadier limed juice pH with fewer fluctuations.

### Results

To try and eliminate the effects of mixed juice quality on the results as far as possible, trials using the "hot" and saccharate liming processes were carried out on the same day.

As saccharate liming was being used continuously during this period three sets of samples, each composited over 45 minutes, were taken during the morning.

The liming process was then changed to "hot" liming and after a period of 3 hours (to flush the process) a further set of three samples were taken.

The results of the analyses are given in Table 1.

From these results, it can be seen that the incoming mixed juice shows no significant difference in quality for either periods and it may be concluded that all changes that have occurred were the result of the liming process used.

Of the three parameters shown to be significantly influenced by the saccharate liming, the effect on turbidity stands out by the visual impact of the clear juice clarity. This effect can be appreciated from the turbidity analyses carried out during the change-over from saccharate to "hot" liming which are presented graphically in Figure 3.

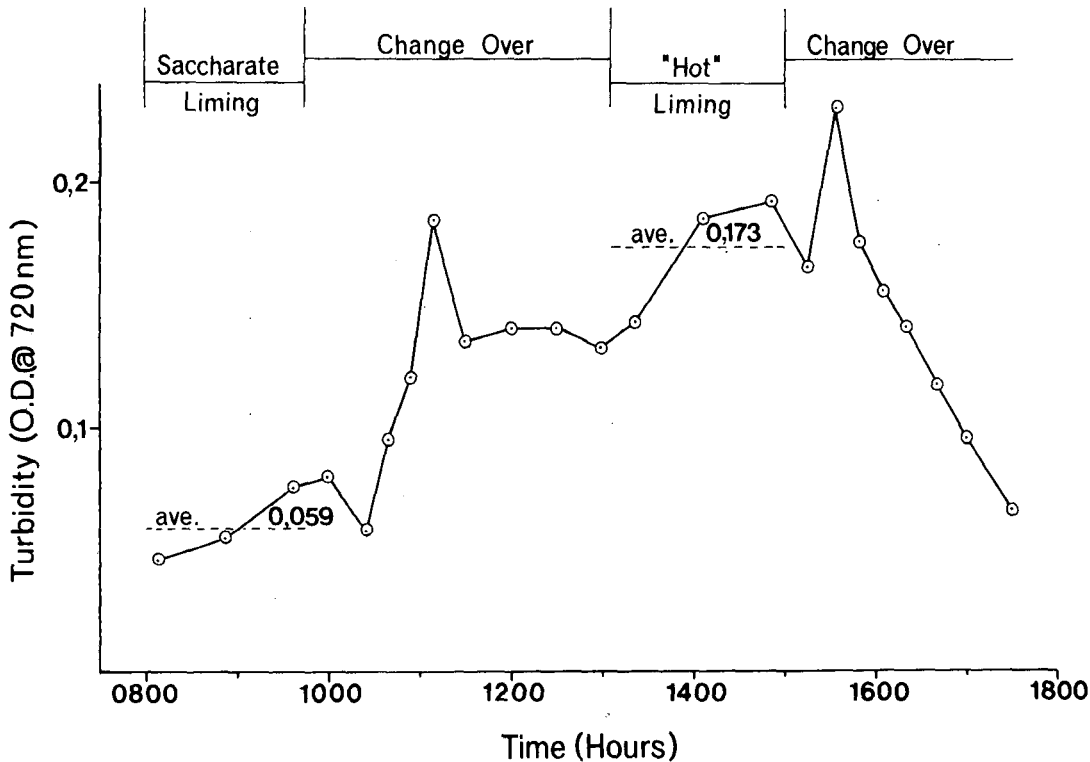
The improvement in the purity of the clear juice was further investigated by analysing the data for the clarifier feed juice and results are given in Table 2.

TABLE 1  
Analysis of the Results for "Hot" and Saccharate Liming

	Liming Procedure				t-Values		Significance
	Saccharate		"Hot" Liming		t Calc.	t 0,05	
	Mean	Std. Dev.	Mean	Std. Dev.			
<b>Mixed Juice</b>							
Purity (Pol/Brix) .. . . .	84,20	1,215	84,26	1,250	0,16	2,02	No difference
RS (%) .. . . .	0,502	0,070	0,515	0,069	0,39	2,11	No difference
RS/Brix .. . . .	4,468	0,615	4,763	0,514	1,13	2,11	No difference
<b>Clear Juice</b>							
Purity (Pol/Brix) .. . . .	84,03	0,697	83,26	1,158	2,72	2,03	Different
RS (%) .. . . .	0,506	0,067	0,561	0,090	2,40	2,02	Different
RS/Brix .. . . .	4,463	0,499	4,905	0,510	2,41	2,03	Different
P <sub>2</sub> O <sub>5</sub> (ppm) .. . . .	20	4,460	22	3,746	1,62	2,04	No difference
CaO (ppm) .. . . .	292	103	272	57	0,60	2,09	No difference
Starch (ppm on Bx) .. . . .	195	152	192	119	0,06	2,02	No difference
pH .. . . .	6,84	0,384	6,96	0,610	0,80	2,02	No difference
Turbidity (o.d. at 720 mm) ..	0,110	0,068	0,178	0,068	3,57	2,01	Different
Colour (a*c at 420 mm) .. . .	27	3,894	28	5,332	0,21	2,01	No difference

**TABLE 2**  
Analyses of the Purity Data for "Hot" and Saccharate Liming

	Saccharate Liming		"Hot" Liming		t-Values		Significance
	Purity	Δ Purity	Purity	Δ Purity	t Calc.	t 0,05	
Mixed juice .. .. .	84,20	—	84,26	—	—	—	—
Clarifier feed .. .. .	83,62	- 0,58	82,81	- 1,45	2,56	2,02	Different
Clear juice .. .. .	84,03	+ 0,41	83,26	+ 0,45	0,16	2,02	No difference
Δ C.J.— M.J. .. .. .	—	- 0,17	—	- 1,00	2,81	2,02	Different



**FIGURE 3** Turbidity Analyses during Change Over.

For both processes, the rise across the clarifier was the same, but a significant difference was evident for the purity drop from mixed juice to clarifier feed. This suggests an improvement in the filtrate quality and mud filtering characteristics. The overall effect has been to improve the purity drop of mixed to clear juice from -1,00, in the case of "hot" liming, to a more normal -0,17 for saccharate.

Although there was a statistically significant difference between the clear juice RS/Brix ratios, it is felt that the actual difference between the mixed and clear juice levels was small enough to be considered normal.

The remaining analyses show no difference between the two clear juice qualities.

**Conclusions**

The saccharate liming process at Pongola gave a clear juice with a far superior clarity and improved the purity drop across the clarification station. Although the mud levels encountered with this process are slightly higher than when "hot" liming is used, no problems were experienced at the filter station after the installation of additional capacity.

Saccharate solutions have a distinct advantage over milk-of-lime suspensions from the aspect of handling and show an improvement in the pH control of limed juices.

**Acknowledgements**

The authors wish to thank the staff of both the Pongola and SMRI laboratories for the numerous analyses undertaken and for their assistance with this project.

**REFERENCES**

1. Davis, C. W. (1962). Clarification and Raw Sugar Filtrability — Recent Improvements in the Lime Defecation Process, *QSST Proc* 29 : 73-81.
2. Mauritius Sugar Industry Research Institute Annual Report (1969) : 137-138.
3. Hartmann, E. M. (1974). The Calcium Saccharate Process, *Sugar Technol. Rev.* 2 (3) : 213-252.
4. Meade, G. P. and Chen, J. C. P. (1977). *Cane Sugar Handbook*, Tenth Edition, Wiley & Sons, New York.
5. Wallace, G. Racecourse Mill, Australia. Private Communication.
6. Wetherill, G. B. (1972). *Elementary Statistical Methods*. Chapman and Hall, London.

## APPENDIX I

Average of the Results for clear juice from the Laboratory Trials (1977-78 Season).

	Saccharate Liming	"Hot" Liming
Flocculant (ppm) .. .. .	3,5	3,5
Colour (a*c @ 420 nm) .. .. .	26	27
Turbidity (o.d. @ 720 nm) .. .. .	0,307	0,615
Final Mud Volume (% after 90 min.)	15,5	14,5
Final pH .. .. .	7,5	7,6

## APPENDIX 2: Sizing of System

Tons cane per hour .. .. .	100
kgs CaO per ton of cane h <sup>-1</sup> .. .. .	0,70
gms CaO / litre of 15° Bè milk-of-lime .. .. .	148
Syrup brix corrected to 50°C .. .. .	64,00
Corresponding density .. .. .	1,309
Purity of syrup .. .. .	85
Pol % syrup .. .. .	54,4
Ratio of sucrose to CaO .. .. .	7:1

## (a) Milk of Lime Required

$$\text{tch}^{-1} * \text{kg Cao} / \text{tch}^{-1} * 1\ 000$$

Density of milk of lime

$$= \frac{100 * 0,70 * 1\ 000}{148} = 473 \text{ litres / h}$$

## (b) Syrup Required

$$\text{tch}^{-1} * \text{kg Cao} / \text{tch}^{-1} * \text{sucrose to CaO ratio} * 100$$

Pol % syrup \* Density of syrup

$$= \frac{100 * 0,70 * 7 * 100}{54,4 * 1,309} = 688 \text{ litres / h}$$

$$\therefore \text{Litres of Saccharate} = 1\ 161 \text{ litres / h}$$

$$\text{Mixing tank size} = \text{litres saccharate / h} * \frac{5}{60}$$

$$= 1\ 161 * \frac{5}{60} = 96,75 \text{ litres}$$