PRACTICAL STEPS TAKEN AT TONGAAT-HULETT SUGAR FACTORIES TO ACHIEVE LOW TARGET PURITY DIFFERENCES

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Abstract

Target Purity Difference (TPD) is one of the most important indicators of performance in a sugar factory. It is not only a good indicator of final molasses exhaustion, but also of back-end factory control. Factors affecting TPD were identified, and practical changes were made to the operations at Darnall in 2003, Maidstone in 2004 and 2005 and Amatikulu in 2005, resulting in significant improvement of TPD values at these factories during the respective crushing seasons.

The paper details the day-to-day boiling house operations that affected TPD results at these three South African Tongaat-Hulett Sugar factories. It further covers the practical application of the Sugar Milling Research Institute crystal size distribution information to improve massecuite and seed boiling procedures, and the effect of slurry preparation on molasses exhaustion.

Keywords: TPD, CSD, molasses exhaustion, panboiling, slurry, centrifugals, factory process

Introduction

Target purity difference (TPD) is an important parameter in sugar processing. For a factory processing about 230 tons cane per hour, one unit of TPD improvement can mean a gain in revenue of approximately R1 million. Therefore, molasses exhaustion is a subject that requires continuous investigation and control. During processing of sugar, there are a number of factors that adversely affect TPD. A study was conducted at the Tongaat-Hulett Sugar factories, where these factors were compared with the practical application of existing theories.

None of the factors that positively affect TPD will assist in achieving low TPDs in isolation. This paper highlights areas of focus at different stages of processing that will impact on TPD.

Factors affecting TPD

A-exhaustion

It is generally accepted that good A-exhaustion will contribute to improved sugar recoveries in a sugar factory. Improving A-exhaustion can also have a positive indirect effect on TPD since it will free-up A-, B- and C-pan capacity and reduce the pressure of throughput in these areas. High A-exhaustion results in a lower overall purity profile in the factory.

This was witnessed in the Darnall operations where an improvement in A-exhaustion levels resulted in a further drop in TPD, after efforts had been made in all other areas to achieve low TPDs. This is supported by Table 1, where an improvement in A-exhaustion was accompanied by an improvement in TPD values. However, this does not mean that, by improving A-exhaustion alone, a corresponding reduction in TPD can be achieved, without addressing other factors that affect TPD. Improved A-exhaustion at Darnall was achieved by increasing the quantity of B-magma and reducing the A-sugar crystal size. This effectively increased the surface area to volume ratio of the sugar crystals and resulted in increased sucrose deposition rates onto the crystals.

Table 1. A-exhaustion and target purity difference (TPD) at Darnall sugar factory.

Season	A-exhaustion (%)	TPD
2000/2001	60.0	3.2
2001/2002	59.9	3.3
2002/2003	63.4	2.5
2003/2004	69.4	1.2
2004/2005	69.8	1.2
2005/2006	69.9	0.7

Slurry preparation

Most Tongaat-Hulett Sugar (THS) factories in South Africa use a slurry made from refined sugar, which has been ball-milled into small nuclei in alcohol or methylated spirit. The slurry is used to grain both B- and C-seed boilings. The quality of the slurry will influence the quality of the sugar crystals in the massecuite. The recommended SASTA Laboratory Manual (Anon, 1985) method of slurry preparation was followed.

The SASTA slurry preparation method has not been implemented in all THS factories. An example of this was found in one factory, where slurry was prepared in two ball mills, one turning at 74 rpm, which is the recommended speed, while the other was turning at 18 rpm. The two batches of slurry were mixed in varying proportions and given to panboilers for graining. On inspection of the seed and massecuite prepared from this slurry, two different crops of grains were visible. Another factory opted for grinding the slurry in the ball mill for 24 hours instead of the recommended 12 hours.

A survey of slurry preparation methods and usage in massecuite boiling was conducted within the THS mills. Table 2 shows the findings for the THS South African factories. The SASTA Laboratory Manual (Anon, 1985) recommendation is included for comparative purposes.

The survey of the equipment and procedures used for preparation of slurry showed that Darnall's preparation method was the closest to the recommended SASTA procedure. Samples of slurry taken from the five mills surveyed were sent to the Sugar Milling Research Institute (SMRI) for photomicrograms to be taken (Appendix 1). Senior sugar technologists from the THS Technology and Engineering Group (TEG) were requested to pick the best sample from the unlabelled photos. The Darnall slurry picture was unanimously picked as the best sample of slurry for massecuite boiling because of regularity of the slurry nuclei. Darnall (DL) TPD figures were the lowest in the industry during the time of this investigation, and one important feature of the C-massecuite was the regularity of the grain size.

Table 2. Slurry preparation and massecuite boiling survey at Tongaat-Hulett Sugar mills during the 2003/2004 season.

Slurry preparation	EN	FX	AK	DL	MS	SASTA
Type of jar	Porcelain	Porcelain	Porcelain	Porcelain	Steel	Porcelain
Volume (litres)	4.5	4.5	4.5	4.5	3.5	4.5
Weight of refined sugar (g)	1000	1000	1500	800	800	800
Volume of alcohol (litres)	5.6	4.0	11.0	6.0	6.0	6.0
Sugar:Alcohol ratio (g/litre)	178	250	136	133	133	133
Grinding time (hours)	24	24	24	12	24	12
Grinding speed (rpm)	66	66	68	58	78	74
Milling ball diameter (mm)	10.0	9.5	9.5	9.5	9.5	10.0
No. of balls in the ball mill	2700	2500	2500	2500	2500	2500
C-massecuite boiling						
Slurry volume (cm^3)	1700	3000	4700	1200	900	-
Seed volume (m^3)	40	85	80	30	56	-
Volume of massecuite (m^3)	80	170	160	60	112	-
Slurry vol:Massecuite vol (cm^3/m^3)	21	18	29	20	8	28*
Seed: Massecuite volume ratio	0.5	0.5	0.5	0.5	0.5	-
C-centrifugal screen slot size (μm)	60	60	60	60	60	-
B-massecuite boiling						
Slurry volume (cm^3)	1000	-	2400	1500	900	-
Seed volume (m^3)	20	-	80	30	56	-
Volume of massecuite (m^3)	40	-	160	-	-	-
Slurry vol:Massecuite vol (cm^3/m^3)	25	-	15	-	-	14*

*Recommended slurry quantities from KwaShukela Training Centre, Panboiling Manual.

Slurry usage in graining

The prepared slurry is used in seed preparation. Since the slurry theoretically contains a fixed number of nuclei per unit volume, a fixed ratio of slurry to final massecuite volume should be used to achieve repeatability of crystal size and crystal quantity in the massecuite. The recommended quantity from the SASTA Laboratory Manual (Anon, 1985) is 50 cm^3 slurry/m^3 of C-massecuite. However, this recommended quantity has proved too high to achieve optimum results since it produces very small crystal size. A lower figure of 28 cm^3 slurry/m^3 of C-massecuite is recommended in the KwaShukela Training Manual for Panboiling.

At the time of this study, THS factories with the lowest TPD results (Darnall and Entumeni) were using slurry to massecuite ratios of around 20 cm^3 slurry/m^3 of C-massecuite, and this became the recommended ratio for THS factories. Using this ratio, the C-massecuite crystal width most closely approaches the recommended 120 microns (Jullienne, 1985).

C-massecuite Brix

Boiling of massecuites is the process of removing water from an impure sucrose solution containing seed grains, which results in dissolved sucrose molecules being deposited onto seed sugar crystals for crystal growth. Therefore, a high C-massecuite Brix will result in high sucrose deposition onto sugar crystals. If however, the sugar crystals in the massecuite do not provide enough crystal surface area due to insufficient slurry, or low crystal content in the seed, false grains may be formed.

On the other hand, very high C-massecuite Brix increases viscosity, which may retard the migration of the sucrose molecules from the mother liquor onto the growing crystals. High Brix C-massecuites may result in challenges in terms of long pan boiling and striking times in batch pans, poor mixing, mobility and cooling in the C-crystallisers, and may necessitate high reheater temperatures to improve flow and curing.

Furthermore, high Brix C-massecuite may slow the massecuite circulation rate and increase the occurrence of Maillard-type reactions, which increases C-massecuite viscosity and adversely affects final molasses exhaustion. Experience at THS factories confirms that no benefits are derived from very high Brix C-massecuite. THS now recommends C-massecuite Brix of 96.5 to 97.5%.

Purities in C-sugar streams

The purities of the syrup or molasses charge and of the feed to the massecuite determine the crystallisation rate in boiling. The higher the purity, the faster the crystallisation takes place and *vice versa* (Sahadeo, 1998). On the other hand, it becomes more difficult to efficiently exhaust the sucrose in the mother liquor if the purities are too high. To ensure increased crystallisation rate for C-seed, it is recommended that slurry be introduced to a graining charge of between 68 and 72% purity.

It is also crucial to determine the targeted C-massecuite purity, which the panboilers should attempt to achieve every time they boil C-massecuites. Failure to achieve the targeted massecuite purity may result in either false grain, poor exhaustibility of massecuite or poor crystallisation rate. If the actual purity is higher than the target massecuite purity, the former two challenges may occur, and if the actual purity is lower than the target, the latter effect may be witnessed.

A tendency by panboilers witnessed at THS factories was that of focusing on factory stocks and working at decreasing the volume of syrup, A- and B-molasses when the boiling house starts filling up. This practice makes it difficult to achieve the targeted purity of massecuite and, on the occasions that the target is achieved, it happens by sheer luck and lacks repeatability. This should not be the case, unless the factory is operating at maximum capacity and a decision has been taken by process management to sacrifice good performance for throughput. The challenges caused by failure to reach the target C-massecuite purity are witnessed downstream when optimum C-nutsch-on-strike and final molasses purities are not achieved.

C-massecuite purity

A computer spreadsheet was developed and used to calculate the target C-massecuite and C-nutsch-on-strike purities. SMRI mixed juice and molasses data from a previous week was used in the calculation, because this data was unlikely to change significantly for the week under evaluation. The data was thus used as inputs into the TPD formula (Smith, 1995), to estimate exhaustibility of massecuite for that particular week.

$$\text{Target Purity} = 43.1 - 17.5\,(1 - e^{-0.74(F+G)/A})$$

If it is assumed that the difference between final molasses true purity and the calculated target purity is the same value as the purity rise on curing, then the purity of molasses in the massecuite after the reheater should be the same as the molasses target purity.

Using the final molasses pol to sucrose ratio, the purity of molasses in the massecuite after the reheater was converted to pol purity. If the traditional purity changes across the reheater and crystalliser are applied, the pol purity of the nutsch-at-strike can be calculated in this way. The pol target purity of C-massecuite was then back-calculated from the crystal content formula, by substituting a recommended crystal content in the equation, together with the molasses pol at strike. If the target purity of C-massecuite is achieved, then there is a good chance that the crystal content will be achieved and the desired purity changes across the crystallisers and reheater will be achieved.

Target purities were calculated for THS factories and compared with the actual purities as given in Table 3. The results show that factories that were frequently boiling C-massecuite purities higher than the target C-massecuite purities in 2003 were achieving poor results on TPD. A comparison with DL figures showed that it is better to err on the lower side of the target C-massecuite purity.

Table 3. Comparison of calculated target versus actual C-massecuite purities.

Week number	C-massecuite purity (%)								
	Darnall			Amatikulu			Felixton		
	Actual	Target	Difference	Actual	Target	Difference	Actual	Target	Difference
10	53.3			65.9					
11	52.1			58.3					
12	50.5	52.8	-2.3	55.9			51.6		
13	53.3	51.8	1.5	57.2	53.9	3.3	55.5	53.2	2.3
14	52.9	52.3	0.6	54.5	54.0	0.5	54.4	52.4	2.0
15	52.2	52.7	-0.5	53.7	53.9	-0.2	54.7	52.5	2.2
16	53.3	52.0	1.3	55.4	53.0	2.4	55.1	52.3	2.8
17	52.9	53.0	-0.1	55.2	54.3	0.9	53.3	53.3	0.0
18	53.2	53.1	0.1	57.0	53.8	3.2	55.8	52.4	3.4
19	52.8	54.3	-1.5	55.8	54.9	0.9	56.4	53.1	3.3
20	52.8	55.5	-2.7	56.2	56.4	-0.2	56.0	54.8	1.2
21	53.0	56.0	-3.0	56.5	56.4	0.1	56.2	55.1	1.1
22	53.3	55.5	-2.2	56.7	56.9	-0.2	54.8	55.4	-0.6
23	53.1	55.3	-2.2	57.5	56.1	1.4	55.3	55.5	-0.2
24	53.5	55.1	-1.6	57.7	56.5	1.2	55.5	55.6	-0.1
25	53.8	55.1	-1.3	58.5	55.8	2.7	57.0	55.6	1.4
26	53.6	54.6	-1.0	56.3	56.3	0.0	57.2	55.9	1.3
27	53.1	54.9	-1.8	58.2	56.0	2.2	56.8	55.8	1.0
28	53.1	54.7	-1.6	56.0	56.4	-0.4	58.2	57.0	1.2
29	52.7	54.5	-1.8	56.1	56.1	0.0	57.3	55.7	1.6
30	52.8	55.8	-3.0	56.1	55.6	0.5	58.9	56.3	2.6
31	53.4	55.7	-2.3	59.9	56.3	3.6	56.6	56.7	-0.1
32	53.5	56.4	-2.9	57.1	56.9	0.2	57.3	56.6	0.7
33	53.4	56.0	-2.6	56.3	57.3	-1.0	57.1	56.0	1.1
34	53.8	55.4	-1.6	57.1	56.8	0.3	57.7	55.7	2.0
35	53.4	55.1	-1.7	58.8	56.0	2.8	57.8	56.2	1.6
36	53.0	54.8	-1.8	58.1	55.9	2.2	56.9	56.1	0.8
37	53.1	54.8	-1.7	58.7	55.1	3.6	56.5	54.9	1.6
38	54.1	53.7	0.4	60.7	55.3	5.4	56.8	54.8	2.0
39	54.6	54.1	0.5		55.5		57.4	54.2	3.2
Final TPD figures									
Season	DL			AK			FX		
2003/04	1.2			5.2			4.5		

Shaded cells = actual C-massecuite purity is higher than the target purity.

C-crystalliser control

Crystallisers serve as another recovery system, where cooling of the massecuite encourages further sucrose deposition from the surrounding sugar solution onto the surface of the sugar crystal. However, owing to the high viscosity of the mother liquor of the C-massecuite, the crystallisation rate is very slow. Although cooling of the massecuite increases the mother liquor viscosity further, it also accelerates the crystallisation process. All THS C-massecuite crystallisers are therefore water-cooled to produce a final massecuite temperature of 37-40ºC. The crystallisers are also stirred to continually expose the sugar crystals to new unexhausted mother liquor. At Darnall a drop of purity on cooling of six units is targeted; values of 5.18% (2003/2004), 5.73% (2004/2005) and 5.43% (2005/2006) have been achieved.

Reheater temperature control

C-massecuite should be reheated to its saturation temperature to reduce the viscosity of the mother liquor prior to centrifuging. This will facilitate easy separation of mother liquor from the sugar crystals on the centrifugal screen. Normally this saturation temperature is assumed to be 52ºC. Although reheating is an essential step to reduce massecuite viscosity, extreme care should be taken to avoid unnecessary crystal dissolution. At DL, the massecuite is heated to 60ºC after a maintenance stop since the massecuite is relatively cold. Once the massecuite is flowing, the temperature is reduced to 54ºC. In this way, an overall purity rise on reheating of less than one unit has been achieved.

Crystal size distribution

Crystal size distribution (CSD) is an important analytical tool that assists process management to make informed decisions to achieve the desired C-massecuite quality. Typically, the CSD data is used to determine the volume of seed required to achieve a minimum grain size width of 120 microns (Jullienne, 1985). At DL, this information is used to adjust the seed to massecuite ratio to achieve the desired crystal content in the continuous pan C-massecuite. In addition to CSD, it is desirable for process staff to review massecuite photos taken by the panboilers for every strike.

C-centrifugal operations

A survey was done on the centrifugal operations at all THS mills. The results of the survey are detailed in Appendix 3. As Appendix 3 depicts, DL clearly has the lowest purity rise on curing (0.6%), with a correspondingly high molasses Brix. Besides the large C-grain size, a major contribution to this low purity rise on curing is DL's meticulous centrifugal screen management and screen cleaning program. DL targets a C-sugar purity between 80 and 82%. Lower C-sugar purity may result in increased non-pol recirculation, while higher purities may increase crystal dissolution and final molasses purity.

DL has adopted the extensive screen management program that is detailed below:

- Once per shift all the screens of the C-machines are washed in position using a water hose.
- Supervisors inspect the screens daily and a day shift maintenance worker replaces dirty screens with caustic soda washed screens.
- Damaged screens are replaced as soon as they are found. The average lifespan of a screens is six weeks.

- On maintenance shut-down day the top covers of machines are opened and feed cones are cleaned to ensure proper feed distribution during the week with minimum machine vibration.
- Inner molasses casings are inspected periodically to check for molasses leaks into the sugar compartment.
- If the purity rise during operation is greater than 1 unit:
  - Supervisors check molasses from each machine for crystals. If crystals are found, it is usually an indication of a hole in the screen, or that the molasses pipe that is situated in the sugar compartment is holed and sugar is entering the pipe.
  - Supervisors also check the temperature of the molasses exiting the machine; if the temperature is too high it implies that operators are using too much steam and hot water, which will dissolve sugar crystals.

Improvements at THS mills

At the beginning of the 2004/2005 season, Maidstone (MS) TPD figures were poor. A number of changes were implemented, based on the experiences gained from the survey conducted in the preceding season. Changes that were made included:

- adjusting slurry preparation grinding time from 24 hours to 12 hours,
- ensuring that sugar nuclei remain in suspension during decanting of slurry after dilution into storage bottles,
- ensuring that C-massecuite purity targets were met on a consistent basis,
- ensuring increased circulation in C-pans by using more jigger steam and reducing calandria steam,
- boiling cleaner C-massecuites with regular grains and free of false grains, and
- boiling C-massecuites at lower Brix to allow for better circulation in the vacuum pan and in the crystalliser.

These changes were all instituted simultaneously in week 24, and the results of these changes were immediately witnessed in week 25, with a step change in the level of TPD achieved as can be seen in Figure 1.

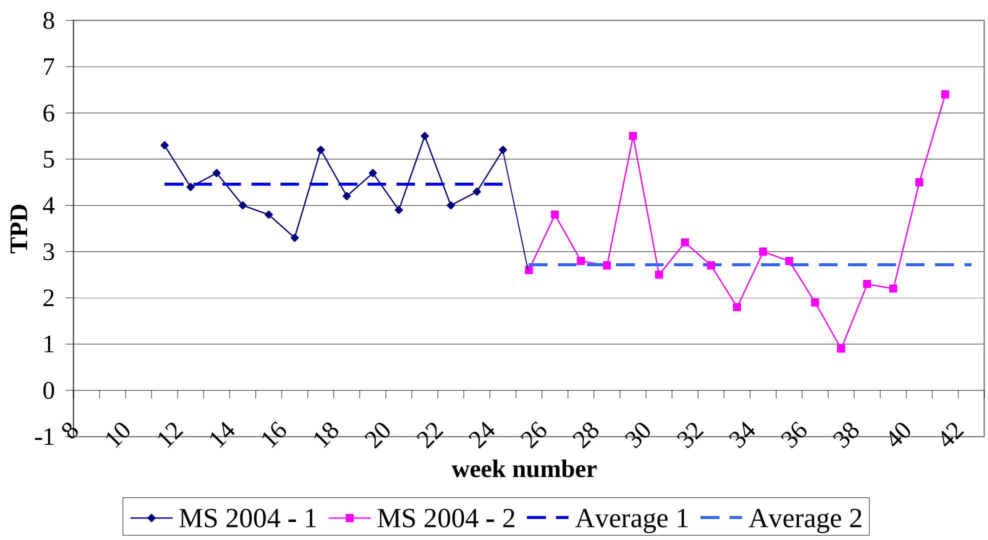

Figure 1. Maidstone target purity difference (TPD) trends, 2004/2005 season.

Except for a spike in week 29, where panboiling challenges were experienced by the mill, and weeks 41 and 42 at the end of the crushing season, Maidstone TPD values remained below 3.8, which was eventually the season average. It was also noted that the TPD values continued to decline after week 25, even during the spring rains, which normally have an adverse effect on exhaustibility of massecuites (Koster *et al*, 1992).

Amatikulu (AK) had also not been performing well on TPD, with to-date figures for the previous two seasons (2003/2004 and 2004/2005) ending up at 6.0 and 5.2 respectively. AK also instituted changes as detailed for MS. A downward trend in AK TPD values produced an average TPD of 4.9 for the period up to week 23 in the 2005/2006 season.

Temperature control in THS factories

It was observed from the SMRI monthly reports that there was a marked difference in the degree of monosaccharide destruction among the South African factories within the THS group. The destruction of fructose occurs particularly in the mixed juice to syrup stages of the factory, due to high processing temperatures at low pH (evaporators), as well as the effects of liming in mixed juice (Schäffler *et al*, 1985). However, the higher degree of inversion, which produces both fructose and glucose in this processing stage, almost balances the amount of fructose in the process stream, thereby hiding the effect of fructose destruction in processing up to syrup.

Some glucose destruction also occurs as a result of liming, but significant destruction of glucose is experienced in the syrup to sugar or molasses stages of the factory. This back-end destruction of glucose is essentially a function of Maillard-type reactions taking place in the factory (Schäffler *et al*, 1985).

The Maillard reaction

There are four conditions that are required for the Maillard reaction to take place (Newell, 1979). These are low purity, high Brix, nitrogen compounds (amino acids) and high temperature. These conditions are all present in varying degrees in the back-end of the factory. Purities start dropping from A-massecuite mother liquor, and drop even further towards final molasses. High Brix happens as early as syrup, while nitrogen compounds are carried through the factory, increasing in concentration towards final molasses. Temperature control in the back-end is one of the parameters that can be used to reduce excessive occurrence of Maillard-type reactions. If product temperatures are reduced, particularly in C-massecuite, then the Maillard reaction and its adverse effects will also reduce. During Maillard reaction, significant quantities of glucose are destroyed, so a measure of glucose destruction is also a measure of the degree of occurrence of Maillard reaction.

Temperature control

In the low Brix section of the process (draft to clear juice), temperature is controlled at higher levels to kill bacteria and reduce the degree of microbiological degradation of sucrose and to improve the rate of reaction in liming. However, from syrup downstream, low product temperatures are preferred, with two main limitations: (i) the super-saturation co-efficient increases, while the diffusion rate decreases as a result of higher massecuite viscosity and this may result in formation of false grains, and (ii) there are physical limitations in terms of installed equipment to cater for high vacuum and very low temperature control.

The higher the temperatures of processing in the back-end of the factory, the more conducive the conditions are for Maillard-type reactions. An indicator of the degree of Maillard reaction occurrence is the glucose ratio or the recovery percentage of glucose from mixed juice to final molasses. A low glucose ratio indicates high glucose destruction and a high level of Maillard reaction. Appendix 2 shows results of temperature readings taken from THS mills, either using a handheld fluke thermometer or control room readings. It is worth noting that MS and DL were operating at lower temperatures in the factory back-end, and had high glucose ratios, indicating reduced Maillard reaction.

Effects on target purity difference (TPD)

Monosaccharides in sugar solutions improve exhaustibility of molasses; that is, sucrose crystallises more easily in a solution that has a higher content of monosaccharides. On the other hand, the products of monosaccharide destruction are polysaccharides that form long chains and have higher molecular weights. These increase the viscosity of sugar streams, retarding crystal growth, and also result in higher sugar colours. It is therefore important to preserve monosaccharides in the factory. TPD is a measure of the exhaustion efficiency, given the prevailing monosaccharide and ash levels in molasses.

Panboilers and process supervisors must have a clear understanding of how and why to control boiling house temperatures at as low a temperature as possible. Every effort must be made to ensure that leaks in pans and evaporators are fixed, to facilitate good temperature control at all times. Where installed condensing and vacuum equipment is inadequate for higher vacuum control, these need to be identified and plans put in place to upgrade, redesign or replace such equipment. Both DL and MS, which were operating at lower temperatures in the back-end were achieving the best TPD results, although further improvements could still be made at MS (see Appendix 2).

Effects of temperature control at THS factories

In the 2005/2006 season, MS TPD values averaged 2.4 until SASA week 23. During this week, more attention was given to reducing temperatures of back-end products, after receiving the results of a temperature profile survey (see Appendix 2) at the THS mills. A dramatic drop in TPD occurred in week 24 after the temperatures were reduced, and this trend continued to the end of season (Figure 2). The average TPD from week 24 to the end of the season was 0.5, which is almost 2 units lower than the early part of the season.

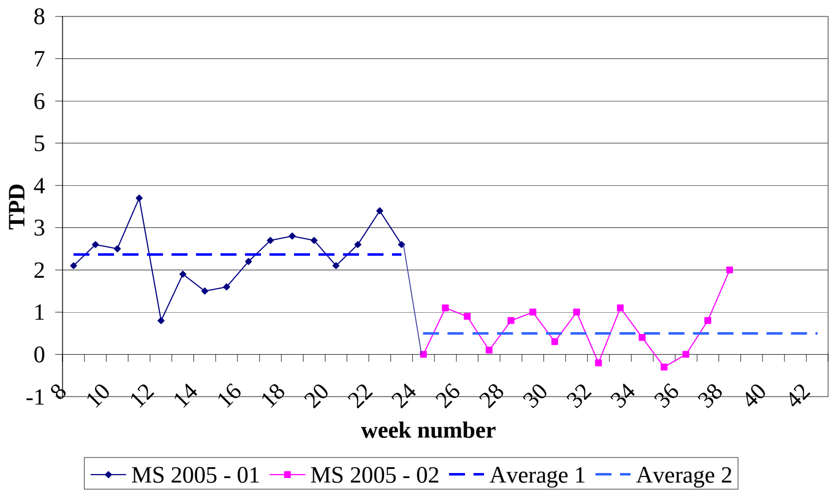

Figure 2. Maidstone target purity difference (TPD) trends, 2005/2006 season.

A similar trend was witnessed for AK, where TPD values before SASA week 23 averaged 4.9, and after increased attention to temperature control, AK TPD averaged 3.4 from week 24 (Figure 3).

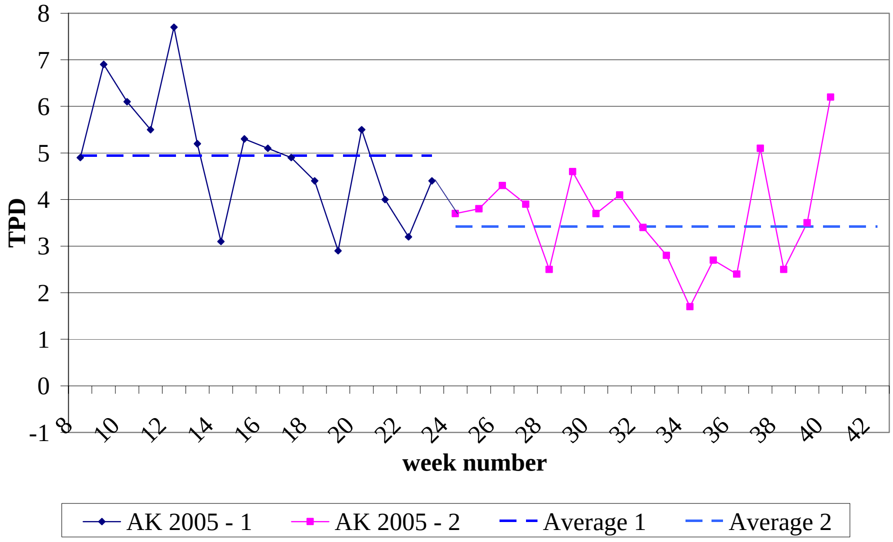

Figure 3: Amatikulu target purity difference (TPD) trends, 2005/2006 season.

Recommendations and Conclusions

The practical steps taken at THS factories to reduce TPDs have given positive results. The improvements are attributed to focus in all areas of processing with emphasis on:

- A-massecuite exhaustions,
- preparation of slurry using the recommended method,
- using a ratio close to 20 cm^3 slurry/m^3 of C-massecuite as a standard,
- targeting C-massecuite crystal width above 120 µm, free of false grains at all times,
- targeting C-massecuite purity according to properties of incoming juice,
- targeting C-massecuite Brix of between 96.5 and 97.5%,
- striving for lower temperatures in operations from syrup to sugar or molasses, and
- conducting regular checks, cleaning and maintenance of centrifugals.

Low TPD values may not be achieved by focusing on one area of the factory; however, the areas highlighted above are believed to have made a large contribution to the low TPD values currently achieved at THS mills.

Acknowledgements

The authors would like to thank THS management for allowing this paper to be published, THS mills staff for their contributions to the surveys, Darnall mill process staff for their willingness to share their experiences, Maidstone and Amatikulu mills process staff for their willingness to try different ways of operating their factories, Dr Raoul Lionnet for his continued contribution and support throughout this project, and Dave Muzzell for his invaluable contribution to the paper.

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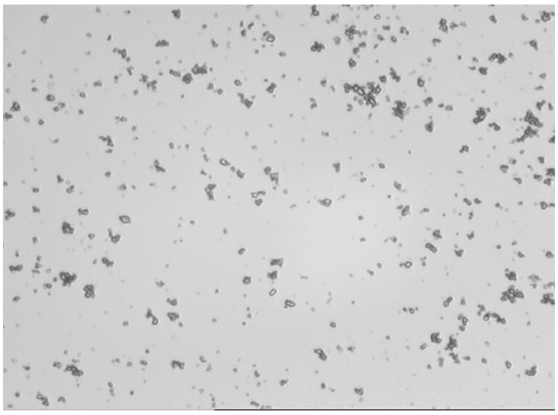
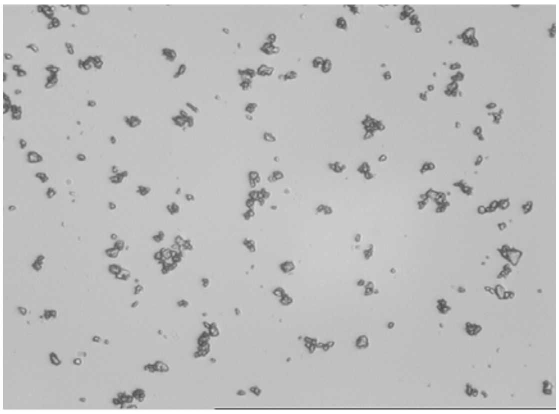
APPENDIX 1: SLURRY

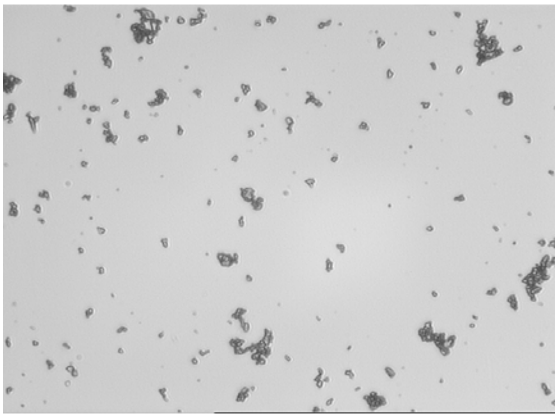
Amatikulu



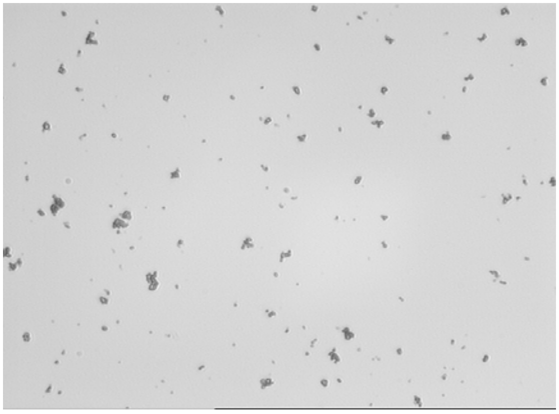
Darnall



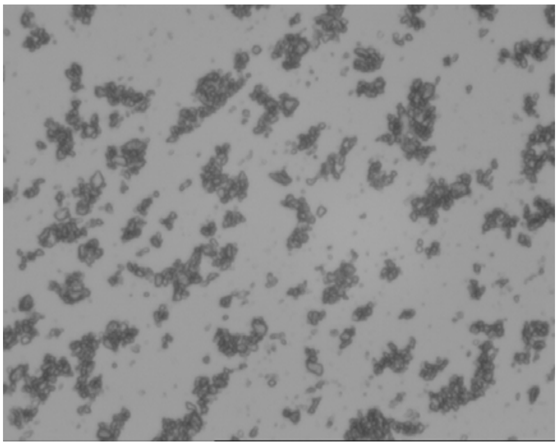
Felixton



Maidstone



Entumeni



APPENDIX 2
Temperature surveys, target purity difference (TPD) and monosaccharide ratios (June/July 2005).

Date	15/07/05		28/07/05		03/08/05		04/08/05	
Mill	Maidstone		Darnall		Amatikulu		Felixton	
	Temperature (ºC)							
Process stream	Fluke Thermo	Control Room	Fluke Thermo	Control Room	Fluke Thermo	Control Room	Fluke Thermo	Control Room
Scalding juice	93.2							
Draft juice ex tandem 1	57.1				60.4		64.0	
Draft juice ex tandem 2	60.6						61.7	
Mill tandem juice			31.6					
Mixed juice ex tank	56.8		31.2		58.9		60.4	
Limed juice	98.8		100.8		100.3		104.0	
Clear juice ex clarifier	95.0		85.5		99.1		99.2	
Filtrate			70.9					
Clarifier Mud			97.7				59.0	
Clear juice into evaps	107.0							
Evaporator syrup ex T1	59.2		57.2		62.0		63.1	
Evaporator syrup ex T2	59.9							
Pan feed syrup	61.2		58.1		62.0		64.0	
A-massecuite:	68.0		60.5	60.0		65.7	70.6	69.0
A-molasses blow up		71.7	69.1		60.6		63.0	
B-massecuite	57.1	59.0		60.0		70.9	68.9	68.0
B-molasses blow up		59.4	70.0		62.1		67.8	
C-massecuite	62.3	59.0	57.9	58.0		69.6	67.6	69.0
Remelt	70.8	74.0	63.6		59.2		72.1	
C-seed		62.0		62.0		58.6	69.0	
B-magma	51.6		42.3		55.6		60.3	
B-seed		63.0		62.0		61.7		
Month	Jun-05	Jul-05	Jun-05	Jul-05	Jun-05	Jul-05	Jun-05	Jul-05
Fructose ratio	0.87	1.02	0.99	0.97	0.83	0.95	0.78	0.85
Glucose ratio	0.69	0.81	0.79	0.68	0.58	0.63	0.55	0.53
TPD	2.2	2.7	0.7	0.8	4.6	3.9	3.5	3.6

APPENDIX 3
C-centrifugal details at Tongaat-Hulett Sugar, 2004/2005 season.

Mill	No. and type of machines	Slot width, screen type	Purity rise C-curing TD (%)	Massecuite temp into machine (ºC)	Mol. temp out of machine (ºC)	Mol. Brix out of machine (%)	C-magma purity (%)	Steam/ water/ both	Average screen life (weeks)	Total tons mol/h
MS	3 BMAs and 2 Broadbents	0.06 mm nickel coated chrome	1.4	58-60	60	84	81	both	6-8	10-13
DL	10 BMAs	0.06 mm nickel coated brass	0.6	50-55	55-65	88	80	both	6	10-13
AK	4 Broadbents and 6 BMAs	0.06 mm chrome plated stainless steel	3.5	60	66	86	81	both	7	16
FX	12 BMAs	0.06 mm nickel coated brass	2.1	55-58	65	85	82	both	4-6	18-24

mol = molasses