"A" MASSECUITE EXHAUSTION AND LOW PURITY "C" MASSECUITE AT MELVILLE

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Abstract

The steps taken at Melville to improve "A" massecuite exhaustion are reviewed and the effects of the improved exhaustion on total production of massecuite are discussed together with the theoretical and practical advantages to be obtained from boiling low purity "C" massecuites. The results of two tests carried out under factory conditions are given.

Introduction

In the 1975/76 season Melville obtained a Factory Performance Index (FPI) of 103,72. The same level of performance by the rest of the industry would result in an additional annual production of 60 000 tons of sugar. It is therefore of great interest to ask ourselves the reason for Melville's high FPI keeping in mind, though, that a high FPI is not necessarily a foolproof indication of factory efficiency. Factors such as the nature of the soluble impurities in the mixed juice or the underestimation of the sucrose content of the juice by the polarimeter method could under extreme conditions have an overriding influence on the FPI. On the more positive side the high exhaustion of "A" massecuites and the boiling of low purity "C" massecuites are two operations in which MV differs quite appreciably from the rest of the industry and which have certainly contributed to the high level of performance.

"A" massecuite exhaustion

The two objectives at the "A" massecuite stage are:

(1) The production of a sugar crystal of the right size and quality.

(2) Crystallization of the maximum amount of sucrose out of the syrup/remelt mixture.

These two objectives are in partial conflict with one another especially under South African conditions where the relatively large specific grain size (0,65 mm–0,75 mm) and high pol (99,3° minimum) make it difficult to obtain high exhaustion.

However, the results obtained at MV in 1975 (Table I) are a clear indication that even under our local conditions relatively high "A" massecuite exhaustion is attainable.

TABLE 1
SEASON 1975

Month	July	August	September	October
"A" mass. purity .	86,1	85,8	87,0	86,7
"A" mol. purity .	64,6	64,6	66,4	64,6
Purity drop . .	21,5	21,2	20,6	22,1
Pol sugar . . .	99,52	99,47	99,41	99,38
SGS sugar (mm) .	0,65	0,65	0,64	0,63
% fines	21	20	23	26

The 1975 "A" massecuite performance is a big improvement over the two previous seasons and is also much higher than the industry's average as illustrated in Table 2.

TABLE 2

	Season	1973	1974	1975
"A" massecuite purity drop	MV	16,2	18,6	21,8
	Industry	16,1	16,2	16,2
Exhaustion. . .	MV	66,2	67,5	71,2
	Industry	64,4	63,6	62,7

It is interesting to note that the better performance at MV has been achieved without any additional equipment ("A" pan capacity 68 m^3, "A" crystallizer capacity 135 m^3 for 80 tons cane per hour) and was the result of a better utilization and control of the existing equipment which made possible—

I. Heavy boilings

II. Extensive cooling in the crystallizers.

I. *Heavy boiling of "A" massecuites*

The boiling of heavy "A" massecuites results in—

(*a*) a drop in the rate of evaporation in the pan;

(*b*) a very likely formation of false grain;

which means that unless certain steps are taken to counteract the above effects the syrup tanks will fill up and the factory come to a halt and/or the difficulty in centrifuging will make the production of a good VHP sugar impossible.

The steps which were taken at MV to make heavy boiling possible were:

(i) reduction in quantity of water to be evaporated by the "A" pans;

(ii) reduction of pan downtime;

(iii) maximisation of the crystal surface area in the massecuite.

(i) *Reduction of evaporation load on "A" pans*

This was accomplished at MV in three different ways. The first and most obvious one was to pay maximum attention to the evaporators in order to get 100% performance at all times. The target at MV is 70° Bx syrup which is frequently obtained at the beginning of the week. It must be borne in mind that a pan handling 60° Bx syrup has 69% more water to evaporate than with 70° Bx syrup.

Another way is to keep a very strict control on the brix of the remelt which, under South African conditions, makes up 20% of the total syrup/remelt mixture. Due to the high quantity of remelt a very substantial evaporation load can be put on the "A" pans if the remelt concentration is neglected. At MV 70° Bx is the aim.

The third way of cutting down on pan evaporation load is to strictly forbid "dilution water" practice. This consists in the pan boiler (very often unnoticed by the process staff) continuously introducing water into the pan while the strike is progressing in order to reduce the risk of false grain formation. It must, however, be pointed out that the "banning" of dilution water can only prove beneficial if the right conditions exist on the pan floor, i.e. a steady steam and vacuum, a supersaturation indication instrument and a large crystal surface in the massecuite.

(ii) *Reduction of pan downtime*

The two main changes made to reduce downtime were:

The conversion of the "A" crystallizers into a continuous arrangement and the adoption of a shorter steaming-out procedure. In the old batch crystallizer arrangement, the "A" massecuite when struck had to move down a low slope gutter to reach the crystallizers some distance away and because of the slow movement of the massecuite the pan could not be emptied in less than 25 minutes. In the new continuous set-up the pan strikes into the first crystallizer, which is directly below it, in less than 15 minutes. The normal practice at MV of steaming out a pan until its inside temperature reached 105 °C took 15 minutes. This was discontinued in 1975 and a standard steaming-out time of 5 minutes was adopted, without any adverse effect on the boilings. The saving in time resulting from the above two changes is a minimum of 20 minutes per strike and at MV with only one striking "A" pan, boiling 8 strikes per day on average, the additional boiling time is 120 minutes or 11% of the available time.

(iii) *Maximisation of crystal surface area*

The boiling of "A" massecuites at high supersaturation level requires a high crystal surface area to accommodate the high rate of sucrose transfer from solution to crystal, and to prevent the formation of false grain. In order to optimise the crystal surface area the process manager using the "B" magma footing system has a combination of three parameters to deal with—one being the size of the "A" crystal at the end of the strike, another the size of the "B" crystal in the magma and the third the footing to "A" strike volume ratio. At MV we work according to two rules:

The first rule concerning the "A" crystal is to aim for the smallest size in the specification, viz. 0,65 mm for South African conditions (Table 3 is an indication of how near to the target MV was during the 1975 season). It is worth noting that in spite of the small crystal size MV was better than average for % fines.

The second rule concerns the size of the "B" crystal in the magma; the bigger it is the higher can be the ratio of magma to "A" strike volume and hence a reduction in the quantity of "B" sugar remelt. There are, however, two drawbacks inherent in the production of a big "B" crystal:

(*a*) a large "B" crystal nucleus in the "A" crystal will adversely affect its quality; and

(*b*) there will be an adverse effect on "B" massecuite exhaustion.

Hence, the second rule followed at MV is to produce a "B" crystal which is just big enough to produce the required size of "A" crystal, using a "B" magma footing to "A" strike ratio of 1:18. During the 1975 season a "B" crystal of 0,3 mm was produced which yielded the results shown in Table 4.

TABLE 3

Month	May	June	July	Aug.	Sept.	Oct.	Nov.
SGS (mm)	0,62	0,62	0,65	0,65	0,64	0,63	0,59
% fines	27	27	21	20	23	26	33
Destination	Hulsar	Term.	Term.	Term.	Term.	Hulsar	Hulsar

II. *Water cooling of "A" massecuites*

The "A" crystallizer station at MV is made up of 8 equal-sized crystallizers of 135 m³ total capacity connected in series (i.e. 1,7 m³/tch—industry average 1,2 m³/tch). Under average working conditions the "A" massecuite is air-cooled for ± 5 hours, in the first four crystallizers, from 55 °C to ± 50 °C and then water-cooled for ± 5 hours in the last four to 39 °C. On cooling, the massecuite gets very "hard" and addition of "A" molasses (78° Bx and ± 60 °C) is used as lubrication.

During the 1974 season tests were carried out at Melville in collaboration with the SMRI to assess the exhaustion performance of the water-cooled crystallizers and the results obtained are summarised in Table 4.

TABLE 4

	On strike	After cryst. 4 (air cooling)	After cryst. 8 (water cooling)
Temperature . . .	55° C	50,5 °C	42,4 °C
Nutch molasses purity	71,8	68,4	66,3
Purity drop per °C .	0,76		0,26

The relatively high purity drop of 0,76 per °C taking place in the first four air-cooled crystallizers cannot be solely attributed to the cooling effect and is, to a large extent, caused by the initial fast rate of crystallization of the massecuites due to their high supersaturation on strike. A better indication of the beneficial effect of cooling on "A" massecuite exhaustion is the 0,26° drop in purity per °C obtained in the four water-cooled crystallizers. Using that figure and working on the basis that MV did 11 °C of water-cooling (50 °C to 39 °C in 1975) equivalent to an "A" molasses purity drop of 2,9° it can be deduced that without water-cooling the "A" massecuite purity drop would have been 18,9° instead of 21,8° which is still much higher than the industry average of 16,2° and is an indication that the good performance at MV is not only the result of water-cooling in the crystallizers.

III. *The effects of good "A" massecuite exhaustion*

High "A" massecuite exhaustion means that a larger number of sucrose molecules are crystallized out at the first massecuite stage, thus reducing the amount of sucrose going to the "B" and "C" stages and coming back to the "A" boiling stage through the remelt.

The reduction in sucrose recycling has three effects:

(*a*) a drop in production of A, B and C massecuites (Table 5 and 6) which is equivalent to an increase in pan capacity per unit quantity of massecuite, and this in turn must generate further improvement in exhaustion;

(*b*) a larger number of sucrose molecules are subjected to a minimum number of boilings thus minimising the risk of sucrose losses and formation of materials detrimental to sucrose crystallization;

(*c*) steam economy.

TABLE 5
MV and Industry — massecuite production over last three seasons

	1973	1974	1975
M³ total mass. per ton brix in m.j. (MV)	1,69	1,46	1,35
M³ total mass. per ton brix M.J. (Industry)	1,67	1,67	1,71

TABLE 6

A, B and C massecuite production at MV over last three seasons — m³ per ton brix in m.j.

Season	"A" massecuite	"B" massecuite	"C" massecuite
1973 . . .	1,12	0,36	0,21
1974 . . .	0,94	0,30	0,22
1975 . . .	0,88	0,26	0,21

"C" massecuite purity level

The high "A" massecuite exhaustion achieved at MV in 1975 resulted in a low purity "A" molasses (64,6°) which allowed "B" massecuites of 65,4° purity to be boiled. The resulting low "B" molasses purity, coupled with the fact that at MV the "C" sugar is single cured and therefore no high purity "C" wash has to be handled, made it possible to produce "C" massecuites at purities as low as 43° at certain periods of the season.

We therefore experimented with boiling "C" massecuites of progressively lower purities, reaching 45° quite successfully at the beginning of July 1975 with a "C" station consisting of:

1 — 30 m³ capacity floating calandria pan;

5 — 34 m³ water-cooled Blanchard crystallizers, connected in series;

3 — 864 mm x 34° continuous Western States centrifugals.

This low level, however, could not be maintained throughout the season and had to be raised to ± 50,0° purity from September onwards to accommodate changes in juice characteristics.

Table 7 shows the purity level used over the season together with the corresponding molasses exhaustion performances.

TABLE 7

MV — "C" massecuite and final molasses purities in 1975

Month	Purity "C" mass.	True Purity molasses	SMRI revised target purity	Differences
May . .	49,7	37,32	36,77	+ 0,55
June . .	49,0	38,35	38,80	– 0,45
July . .	47,9	36,79	38,47	– 1,68
August .	50,1	36,23	37,54	– 1,31
September	50,7	39,47	40,10	– 0,63
October .	51,2	40,39	40,93	– 0,54
November	50,9	41,40	40,52	+ 0,88

Table 8 illustrates the theoretical advantages to be derived from the production of a low purity "C" massecuite as compared to a higher one, using 48° and 55° as an example, and assuming a final molasses purity of 35° and a "C" sugar purity of 85° in both cases. (See Appendix)

With the 55° purity "C" massecuite there is 91% more sucrose to be crystallised per unit pan capacity. There is also a 19% drop in crystallizer retention time. There is, however, a slowing down in the crystallization rate in the lower purity medium which could be important enough to cancel out the favourable effects. In our example if the crystallization rate is reduced by more than 91% no advantage is gained from the low purity boiling.

TABLE 8

Theoretical differences between 48° purity and 55° purity "C" massecuites

	48° purity	55° purity
Quantity of massecuite boiled	100	124
Crystal content in unit quantity massecuite .	100	154
Quantity sucrose to be crystallized in unit time	100	191
Retention time in crystallizers	100	81
Molasses per unit quantity of massecuite . .	100	81

The results of two tests (Table 9) carried out at MV under factory conditions are, however, strong indications that, with the particular characteristics of juice prevailing at that time, the smaller quantity of sucrose to be crystallized at 47/48° purity more than made up for the reduced crystallization rate.

TABLE 9

Factory test results

Test No. 1

Date	"C" massecuite purity	Molasses purity on strike	Purity final molasses
1/8/75. . .	48,5	34,6	
			29,6
2/8/75. . .	49,7	33,9	
	48,7	36,4	
			29,9
3/8/75. . .	48,0	35,3	
4/8/75. . .	**51,6**	**35,7**	
			30,4
5/8/75. . .	**51,2**	**36,5**	
	48,0	35,8	
			30,0
6/8/75. . .	48,4	34,5	
	48,0	35,3	29,8
Test No. 2			
13/8/75 . .	47,4	34,2	
	48,0	34,4	
14/8/75 . .	**52,3**	**36,4**	
	53,5	**36,5**	(N.R.)
15/8/75 . .	**50,0**	**35,3**	
	48,8	33,8	
16/8/75 . .	47,7	32,1	

Practical aspects of low purity "C" massecuite:

1. *"C" massecuite production*

   As already shown in Table 8 there is, in theory, an important drop in "C" massecuite production when the purity is lowered. Table 10 using MV factory figures for the last five years shows the practical confirmation of this theory.

2. *High molasses content*

   The higher molasses content of a low purity massecuite increases its "fluidity". This certainly helps pan circulation and also exhaustion in the crystallizers. In addition it eases the passage of massecuites through the reheater and piping.

3. *Reduction in crystal content*

   The lower crystal content results in a smaller surface area being available for crystallization. It is our experience at MV, where the season average "C" grain size was 0,19 mm, that this is not critical because there is no formation of false grain on "tight" boiling.

TABLE 10

"C" massecuite production at Melville over the past five seasons

Season	Purity of "C" massecuite	m^3 per ton non-pol in mixed juice	m^3 per ton non-sucrose in final molasses
1971 . . .	58,6	1,66	2,31
1972 . . .	60,7	1,91	2,51
1973 . . .	54,6	1,50	1,98
1974 . . .	51,2	1,54	1,75
1975 . . .	50,1	1,37	1,62

4. *Centrifugal capacity*

With low purity "C" massecuites the rate of curing, expressed as volume of massecuite per unit time, is reduced. The real criterion of "C" centrifugal performance is, however, the quantity of molasses purged in unit time and this is not greatly affected due to the higher molasses content of the lower purity "C" massecuite. The curing rate per centrifugal at MV when handling "C" massecuites of ± 48° purity, reheated to ± 51 °C, was ± 1 m^3/hr. This is equivalent to 1,23 m^3/hr of 55° purity massecuite for an equal molasses yield.

Conclusions

1. The 1975 MV results are a clear indication that, in spite of the high South African sugar specifications, much higher "A" massecuite exhaustion than presently obtained in the industry could be achieved with proper boiling and cooling techniques.

2. The quality of the sugar produced at MV from the better exhausted "A" massecuites compares well with the rest of the industry as well as with the MV sugars of previous seasons.

3. The important reduction in total quantity of massecuite boiled, which accompanies an improvement in "A" massecuite exhaustion, is a very positive way of increasing pan capacity and hence factory performance as well as fuel economy.

4. Our experience in boiling low purity "C" massecuites, though still limited at this stage, has been conclusive enough to allow us to state with confidence, that the optimum "C" massecuite purity is the lowest that the pan can boil.

5. In the light of the above conclusion, it is felt that elimination of any non-essential practices (double curing of "C" sugars being an obvious one in many cases) which have a tendency to raise the minimum "C" massecuite purity attainable, ought to be considered.

Appendix

Calculation of the theoretical differences between 48° and 55° purity "C" massecuites

1. Assumptions:

   The calculations are based on a "C" molasses purity of 35° and a "C" sugar purity of 85° in both cases.

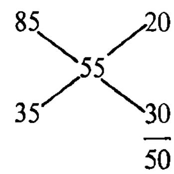
2. Basis of calculation:

   The weight of non-sucrose in final molasses is the same for both massecuite purities and because it is assumed that the final molasses will be of the same purity the weight of brix in "C" molasses is also the same.

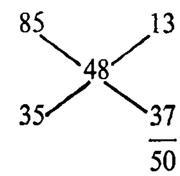
3. (*i*) *Weight of "C" massecuite*

   Using Coblenz Formula:

55° PURITY



48° PURITY



Weight of brix in "C" massecuite

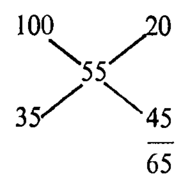
$= \frac{50}{30}$ Weight of brix in "C" molasses $= \frac{50}{37}$ Weight of brix in "C" molasses

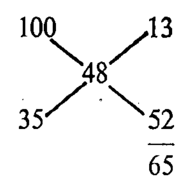
$= 1,67$ $= 1,35$

∴ Ratio of 55° purity to 48° purity "C" massecuite $= \frac{1,67}{1,35} = 1,24$

(ii) *Weight of sucrose crystal in unit weight of "C" massecuite*

Using Coblenz Formula:





∴ Weight of crystal

$= \frac{20}{65}$ Weight of massecuite $= \frac{13}{65}$ Weight of massecuite

∴ Ratio of weight of crystal in unit quantity of 55° purity "C" massecuite to weight of crystal in same quantity of 48° purity "C" massecuite is $\frac{20}{13} = 1,54$.

(iii) *Weight of sucrose to be crystallized in unit time*

The ratio of sucrose to be crystallized in unit time
= ratio of "C" massecuite quantity × ratio of sucrose crystal in unit quantity of massecuite.
= 1,24 × 1,54
= 1,91.