

# MODIFIED BOILING SYSTEM FOR BETTER SUGAR QUALITY

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## Abstract

A new boiling system for the production of improved VHP sugar is proposed. This modified scheme requires only minor changes to pipe-work in the factory and it is estimated that steam consumption will only be increased marginally.

## Introduction

In July 1962<sup>1</sup> a new boiling system was proposed which, although in a slightly modified form, became universally accepted by the South African sugar industry. The main characteristics were:

- C<sub>1</sub>-Sugar:* Double-cured after being made into a magma with B-molasses.
- C<sub>2</sub>-Sugar:* Remelted after double curing at a purity of approximately 85.
- C-Wash:* Mixed with B-molasses.
- C-Masseccuite:* Grained on molasses of approximately 72 purity and boiled off at 57,5 purity.
- B-Masseccuite:* Grained and boiled on A-molasses. In principle B-masseccuite and A-molasses had identical purities.
- B-Sugar:* Well washed B-sugar of about 97 purity was made into a magma with syrup and used as a footing for A-masseccuite. Excess magma was remelted.

Together with other measures, such as enzymatic removal of starch, this boiling system, which replaced the "single magma method", was responsible for a dramatic improvement of the raw crystal quality. When the final molasses was then replaced with a low ash - high reducing sugar liquor (high test molasses) for the purpose of coating, South Africa produced the best raw sugar in the world in terms of colour, crystal size and regularity, potential refinery yield and moreover, the pol could be varied to any desired level.

During a panel discussion in June 1982<sup>2</sup> the gradual increase of the export sugar quality of our competitors was discussed. It was realised that, in order to maintain its position at the top of the ratings, the South African sugar industry would have to look at its own position again and evaluate various possibilities to increase their average quality by obviating the effects of the higher extractions, introduction and proliferation of diffuser installations, gradually decreasing cane quality, etc.

The purpose of this paper is to highlight the change of conditions which has taken place in the factory, to discuss their possible influence on sugar quality and to suggest further improvements.

## Changes in Sugar Manufacturing Techniques

Since the partial remelt boiling system was introduced, the following changes have taken place:

- (1) Double curing of C-sugar is not practised any more and a *C<sub>1</sub>*-sugar of 80-82 purity is remelted instead of a 85-86 purity, *C<sub>2</sub>*-sugar.
- (2) Continuous B-centrifugals were introduced with two profound effects:
  - (a) The purity of B-sugar dropped from 95-97 to 90-92.
  - (b) The B-sugar crystal size became much smaller and also far more irregular as a result of crystal breakage.

- (3) The purity levels of C- and B-masseccuites became much lower and the crystals were more prone to contain colour.
- (4) The A-masseccuite purity dropped relative to the syrup purity as a result of the increased non-sugar and colour circulation.
- (5) A-crystal size became smaller and less regular.

These developments were, in themselves, justifiable. Extraction improved and capacity was expanded at low capital cost, cheaper, fewer continuous centrifugals became standard and molasses exhaustion improved. However, as overall recovery improved the sugar quality did not!

## A New Proposed Pan Boiling System

In the opinion of the author, the disadvantages which were introduced can be corrected with a slight variation in boiling scheme, which, in general, will not require additional or different equipment. A mere re-allocation of duties will suffice. The following are the proposals, with their advantages:

- (1) *C-Sugar*  
All C-sugar to be magmarised with warm A-molasses and to be used as footing for B-masseccuite.
  - (a) When low purity C-sugar is drawn in the B-pans the coating of final molasses is replaced by a coating of B-molasses. This is the same effect that would be achieved by aftercuring, only more complete. The recycling of final molasses is thus restricted from two stages to one stage.
  - (b) The purity of C-sugar in the present boiling system must be maintained above a minimum level in order to maintain the highest possible purity of A-masseccuite. The proposed scheme will allow for greater freedom and lower purities and higher brixes of molasses may well result.
- (2) *B-Sugar*  
All B-sugar is remelted at a purity in excess of 93, so all melt will be of 93 purity at least.
  - (a) The lowest possible non-sugar, and in principle therefore colour quantities, is recycled over A-masseccuite.
  - (b) The irregularity of the B-crystal is no longer of significance, as it will not influence A-crystals.
- (3) *A-Sugar*  
A-sugar is grained on slurry in A-pans and built up to the required grain size by cutting to seed receivers and other pans.
  - (a) A very good regular grain will be achieved.
  - (b) There will be no coloured nuclei of B-crystals in A-crystals.
- (4) *Purity of C-Masseccuite*  
This purity is dictated by the requirements of a good recovery and will be in the region of 52. No boiling system could be contemplated if it would endanger the low level of C-masseccuite purity, even when the syrup purity is high.
- (5) *Purity of B-Masseccuite*  
This purity is increased as a result of the masseccuite being built-up of C-sugar of 80 purity and A-molasses, instead

of A-molasses only. The B-molasses purity would then also increase and the requirements under (4) become endangered.

(6) *Purity of A-Molasses*

It is therefore necessary to consider steps to reduce the purity of A-molasses in order to counteract the possible effects of (5). This will be done in two stages:

- (a) The better, more regular, A-crystals will wash easier and some advantage in A-exhaustion may be expected.
- (b) Classification of A-molasses, not practised any more in South Africa, can be re-introduced. In this respect the author concurs with R. D. Archibald, who made this suggestion during the panel discussion in 1982.<sup>2</sup> He has measured that the purity of green molasses is 3 units lower than the mixed A-molasses and the wash would be 10 units higher than the average.<sup>3</sup>

This would mean that 100 units of brix in massecuite of 86 purity with 65,0 average exhaustion would leave 33,2 units of brix in green of 65,25 purity and 10,0 units of brix in wash with 78,25 purity (sugar assumed at 99,4 purity), roughly a 3:1 ratio. A more recent study has indicated that these purity differences may be too high.<sup>4</sup> Obviously, a fair degree of variation will be found as a result of differences of intensity of the washing process and desired pol of A-sugar. The A-greens would assist in obtaining a lower purity of B-masseccuite, whereas the A-wash would be returned to the A-masseccuite, where it would have, unfortunately, a purity depressing effect.

(7) *Influence of A-wash return on A-Masseccuite*

The purity depressing effect of A-wash is to be preferred over the present practice of returning final molasses as part of melted C-sugar. The non-pol in A-molasses is "fresh" and has not deteriorated in further stages from point of view of colour, viscosity and/or other decomposition products. Generally speaking, an efficient crystallisation process will endeavour to move the non-crystallisable products to the lower stages as fast as possible, without allowing them to return to the first stage.

Nevertheless, the A-wash return is objectionable but has to be tolerated when syrup purities are in excess of 85 as will be seen later. A positive move would be to keep the A-wash separate from the syrup-melt mixture. The wash could then be drawn in as the "last drink" before striking. The result would be that not only the purity of the mother liquor would be minimal just before the end of the process, but also the last sugar to be deposited, possibly having a higher colour, would be washed off again.

A profound advantage, however, is that all material not moving to the B-stage will have the effect of a reduction in B-masseccuite quantity, as will be seen later.

**Comparison of the Present and Proposed Systems**

Mass balances of the two systems are attached in Annexures I, II, III, IV and V. The calculation technique is the same as the one described in 1962.<sup>1</sup> A few remarks are necessary:

- (1) No allowance is made for losses in the panhouse. This, however, is insignificant as the diagrams are used for comparison only.
- (2) The syrup purity in South Africa varies mainly between 85,0 and 87,5 and therefore examples are worked out for these two purities only.
- (3) The possible advantages which may occur, such as a more efficient split between A-green and A-wash, higher B-sugar purity etc. have not been allowed for. Also, the B-sugar

purity, with larger crystals, is likely to be higher than 93.

- (4) The diagrams were hand calculated and will show a few insignificant rounding-off inconsistencies.

In the annexures, five different schemes are given:

- Annexure I: The present system at 87,5 purity syrup.
- Annexure II: The proposed system at 87,5 purity syrup.
- Annexure III: The present system at 85,0 purity syrup.
- Annexure IV: The proposed system, inclusive molasses classification, at 85,0 purity syrup.
- Annexure V: The proposed system, exclusive molasses classification, at 85,0 purity.

The quantities of massecuite boiled can be calculated by assuming that 1 000 tons brix in syrup is identical to 1 020 tons brix in mixed juice, allowing for average cake and undetermined losses and purity rises from mixed juice to syrup. These quantities are tabulated hereunder.

**TABLE I**  
Quantities of massecuite boiled

Per 1020 tons brix in mixed juice	REFERS TO ANNEXURE:				
	I	II	III	IV	V
Tons brix in A-mc	1390	1390	1361	1362	1336
Tons brix in B-mc	551	520	498	481	658
Tons brix in C-mc	295	295	357	357	357
Purity of syrup	87,5	87,5	85,0	85,0	85,0
Purity of A-mc	88,0	88,0	85,8	85,6	87,0
Purity of B-mc	72,0	71,2	67,7	68,8	72,0
m <sup>3</sup> /ton brix* in A-mc	1,00	1,00	0,98	0,98	0,96
m <sup>3</sup> /ton brix* in B-mc	0,38	0,36	0,34	0,33	0,45
m <sup>3</sup> /ton brix* in C-mc	0,20	0,20	0,24	0,24	0,24
M <sup>3</sup> /ton brix in total mc	1,58	1,56	1,56	1,55	1,65
Exhaustion A-mc	64,9	64,9	65,3	65,0	65,0
Exhaustion B-mc	61,0	59,5	59,4	59,8	61,1

\* tons brix refer to tons brix in mixed juice

N.B. All massecuite quantities are calculated with average densities of massecuites (A = 1,49; B = 1,51 and C = 1,53).

**Discussion**

(1) *Level of Exhaustion*

An effort was made to calculate the schedules in such a way that there is no great difference in the levels of exhaustion in any of them. It is considered that 65 for A and 60-61 for B are average exhaustions under South African conditions and cannot be considered extreme in any way.

(2) *Purity of A-Masseccuite*

The purity of A-masseccuite is virtually the same whether the present or the proposed boiling scheme is operated. The purity rise is between 0,5 and 0,8, the difference being larger for the lower syrup purities. Significant, however, is that in Scheme V the purity rise is 2 units on account of no A-wash being circulated over the A-masseccuite. So, if the exhaustions of A- and B-masseccuite are good enough to allow C-masseccuite purities of 52,0, it could be beneficial not to operate an A-molasses classification system. In the author's opinion that will not be possible when syrup purities are over 87,0.

(3) *Quantity of A-Molasses*

As is to be expected, the quantity of A-masseccuite per ton brix in mixed juice reduces with syrup purity and even more so when no molasses classification is applied. The quantity is basically controlled by the A-sugar which will be produced.

(4) *Purity and Quantity of B-Massecuite*

Any volume of A-molasses returned to A-massecuite will prevent the production of B-massecuite. This is clearly demonstrated by Scheme V where the quantity of B-massecuite jumps from around the 0,35 mark to 0,45m<sup>3</sup> per ton brix in mixed juice. The explanation is easy: unless A-molasses quantities are reduced, the recirculating C-sugar will increase the volume of B-massecuite significantly. This, in itself, need not be too disadvantageous, as after all the extra sugar in the B-pans is crystallised before entering. Nevertheless, the efficiency of molasses classification in reducing massecuite volumes is clearly illustrated. The necessity to apply classification or not may be changing from time to time and factory to factory. However, the larger the B-massecuite volume, the larger the purity rise will be from syrup to A-massecuite.

(5) *Equipment Required*

As massecuite volumes will hardly change, the pans will be able to cope without difficulty.

However, in the present system we store B-magma and in the proposed system this will be C-magma. The volumes will be about the same.

In the present system A-seed receivers are not required although available in many factories. On the other hand, most factories have B-seed and/or C-seed receivers which can be converted to A-seed receivers.

When molasses classification is not applied, the quantity of B-massecuite increases and this would require a larger

B-centrifugal station. On the other hand, the B-grain will be larger and will cure easier. This will tend to increase the capacity per centrifugal, partly off-setting the disadvantage of the larger B-massecuite volume.

(6) *Steam Requirements*

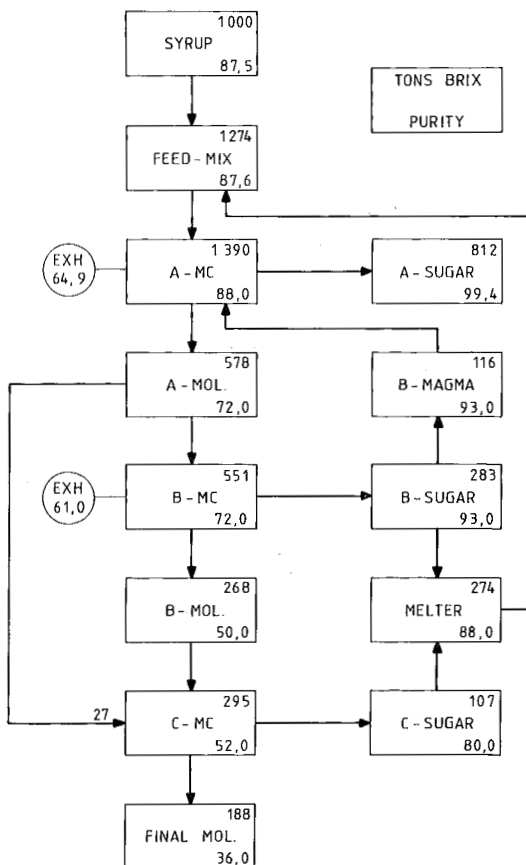
In the present system all C-sugar and a large part of the B-sugar are remelted. In the proposed system, all B- and C-sugar are remelted. The steam requirements of the pan-floor will then increase. A further increase will result from not applying molasses classification.

The question is: how much extra steam is required? The schedules are calculated by assuming that one-twelfth of brix in A-massecuite is from B-sugar. So, if all massecuite contains approximately 2 200 tons brix, the extra brix of 116 tons is approximately 5%. It is therefore estimated that the steam consumption may increase by 0,5 to 0,7% on cane allowing for the fact that the pans will operate on vapour I. This estimate will probably be too high as the extensive washing of B-grain in the A-pans will not be necessary any more. In a raw sugar factory this will be of little consequence.

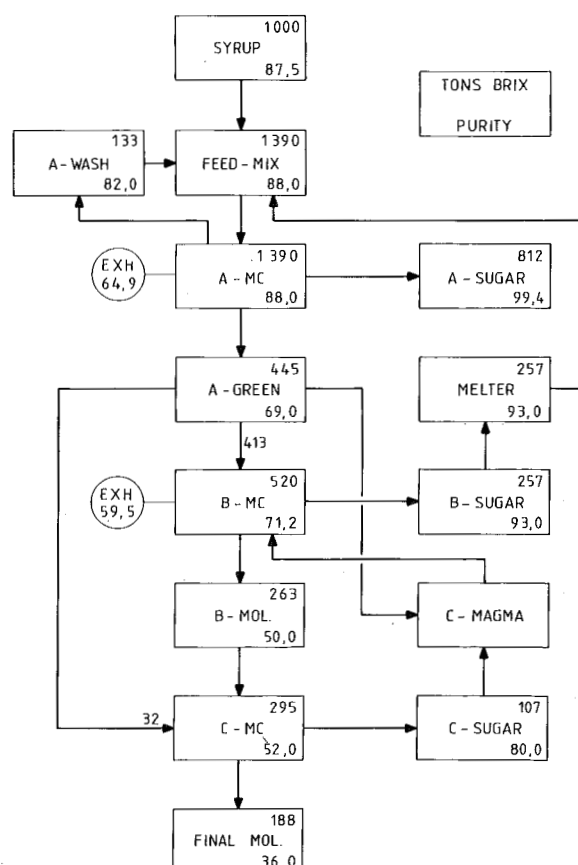
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- 1 A. van Hengel (1962). Better Sugar by Remelting, S.M.R.I. Quarterly Bulletin No. 23, July 1962.
- 2 R. D. Archibald (1982). Panel Discussion on Raw Sugar Quality, SASTA Proc. 56.
- 3 R. D. Archibald (1983). Private Communication.
- 4 L. M. S. A. Jullienne (1983). Private Communication.

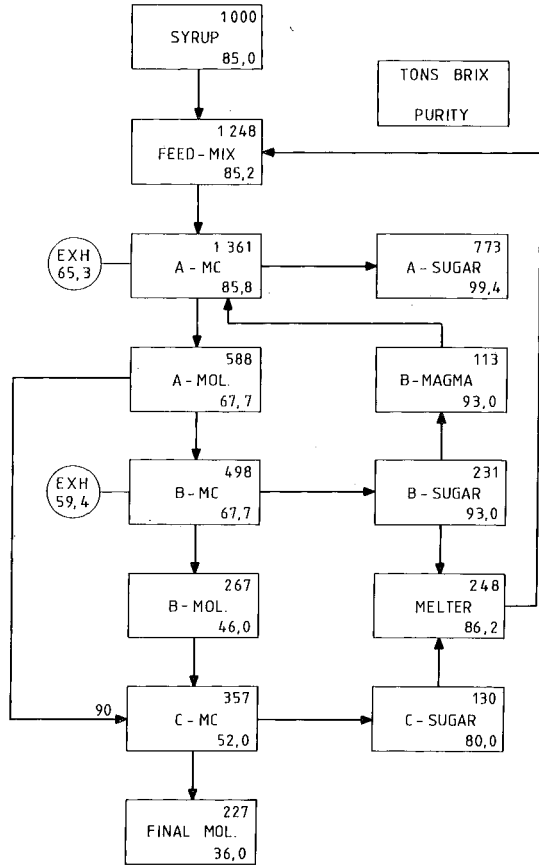
ANNEXURE I  
PRESENT BOILING SYSTEM



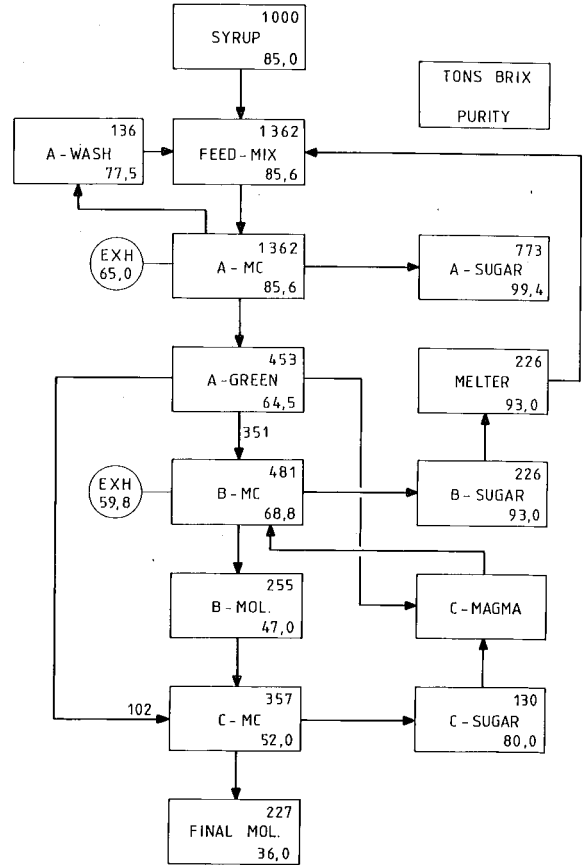
ANNEXURE II  
PROPOSED BOILING SYSTEM



**ANNEXURE III  
PRESENT BOILING SYSTEM**



**ANNEXURE IV  
PROPOSED BOILING SYSTEM**



**ANNEXURE V  
PROPOSED BOILING SYSTEM**

