

THE AFFINATION OF B-SUGAR AT NOODSBERG

¹MA GETAZ, ¹D PILLAY, AND ²LMSA JULLIENNE

¹*Illovo Sugar Ltd, Noodsberg*

²*Illovo Sugar Ltd, Technical Services, Durban*

Abstract

Facilities to affinate B-sugar were installed at the Noodsberg mill in 1993. The installation has been fully operational during the 1994 season and the affinated B-sugar has been used as refinery feed material. The performance of the process and its effect on different factory operations are discussed.

Introduction

The three-boiling, partial remelt system was proposed for use in the South African industry in the 1960s in the interests of producing a better raw sugar quality (van Hengel, 1962). This boiling system, together with some other measures, made possible the adoption of very high pol (VHP) specifications for all the raw sugar produced in South Africa. The measure of success of this boiling scheme in South Africa has been its universal use, virtually unchanged, for a period of more than 25 years.

This VHP boiling system does, however, suffer from the disadvantage that the remelting and recycling of the B- and C-sugars result in a higher degree of equipment and energy usage and increase the chances for destruction of sucrose and formation of undesirable degradation products. Jullienne (1990) has pointed out that the high purity B-sugar crystal is particularly poorly utilised in this boiling system. He postulated that this B-crystal could be transformed into a good quality product sugar provided it could be separated from its surrounding low purity molasses film.

In this regard a sugar mill with a back-end refinery, which has a high purity and low colour run-off return to the raw house, has available an ideal affination liquor for B-sugar, that is, the refinery return syrup could be mingled with the B-sugar making a magma with a high purity liquid medium. This magma could then be cured again giving a good quality raw sugar, which could then be sent direct to the refinery. A sugar mill with a back-end refinery was also considered to be more severely disadvantaged by the higher energy utilisation of the partial remelt boiling scheme because of the additional steam consumption the refinery imposes. The additional energy requirements would generally need to come from burning an auxiliary fuel (e.g. coal) to supplement a shortfall in the availability of bagasse for this purpose. The feasibility of this process by way of pilot plant testing was therefore further investigated.

These pilot plant affination tests, which were carried out by the SMRI (Getaz, 1990), confirmed that provided certain criteria were met, the affination of B-sugar with the refinery returns was practical and that the affinated sugar would be of a quality which would make it suitable for use as a refinery feed material. One criterion determined to be of paramount importance was that the forecured B-sugar crystals should be relatively undamaged and therefore conventional continuous centrifugals could not be used for curing B-sugar.

Implementation of B-affination at Noodsberg

Based on the results of the SMRI pilot plant tests it was estimated (Jullienne, 1990) that the adoption of B-sugar af-

fination by a factory with a back-end refinery would result in a 15% reduction in the quantity of A-masseccuite boiled and a 21% reduction in the quantity of B-masseccuite. It was also determined that these reductions in the amount of masseccuite produced would give a 1.6 percentage point reduction in the steam % cane required. Noodsberg (NB) has a large back-end refinery, which also takes in a substantial quantity of additional sugar, mainly from the Union Co-op mill (UC), for processing into refined sugar. In addition NB's A- and B-stations have often proved to be capacity limiting areas which have not only constrained the factory crush rate but also resulted in a significant number of "back-end full" production stoppages. Noodsberg therefore presented an obvious target for adoption of the proposed B-affination process.

There were, however, several obstacles that needed to be overcome. The requirement that the B-sugar crystal be undamaged and the need to provide centrifugals for after-curing were two of these. It has been shown that the use of continuous centrifugals with large diameter monitor casings results in significant reduction in the degree of crystal breakage (Rein and Archibald, 1989). However, retrofitting "wide casings" to the existing centrifugal station not only required re-positioning of the centrifugals; but it was also constrained by the floor space available. In an evaluation of the worth of B-crystallisers, Jullienne (1991) noted that using less B-crystallisers (with out water cooling) could result in reduced centrifugal requirements because of the increased capacity of the machines arising from lower viscosities of the "hotter" masseccuite. In practice it was discovered that using only half the installed B-crystallisers resulted in a reduction in requirement for B-centrifugals of almost half the installed capacity. This thus paved the way for the possible economic implementation of B-affination.

At the time this experimentation and investigation was taking place deterioration (corrosion) of the supporting steel work of the NB B-centrifugal station had reached a stage which required its complete renewal. This meant that all the centrifugals had to be removed to enable the repairs to be effected. It was therefore decided to take this opportunity to make the necessary plant changes which would enable the B-affination process to be implemented.

The NB B-station originally consisted of $2 \times 45 \text{ m}^3$ vacuum pans, $8 \times 45 \text{ m}^3$ crystallisers and six BMA continuous centrifugals ($3 \times \text{K1000}$ and $3 \times \text{K850}$). B-affination, as implemented at Noodsberg, consists initially of producing B-masseccuite conventionally from A-molasses and then using only four of the original crystallisers to serve as strike receivers. The B-masseccuite (ca. 63°C) is then cured in the three BMA K1000 machines (which were each fitted with a 4.2 m diameter monitor casing) to produce a B1-sugar of around 92 purity and B-molasses with a purity in the range 42-49.

The B1-sugar is then mingled with fourth run-off returns from the refinery to make a B1-magma of around 90° brix. Additional buffer storage needed for the fourth run-off and B1-magma is accommodated by using two of the redundant B-crystallisers. The B1-magma is then cured again in the three K850 centrifugals to produce the affinated B2-sugar at a target purity above 99.

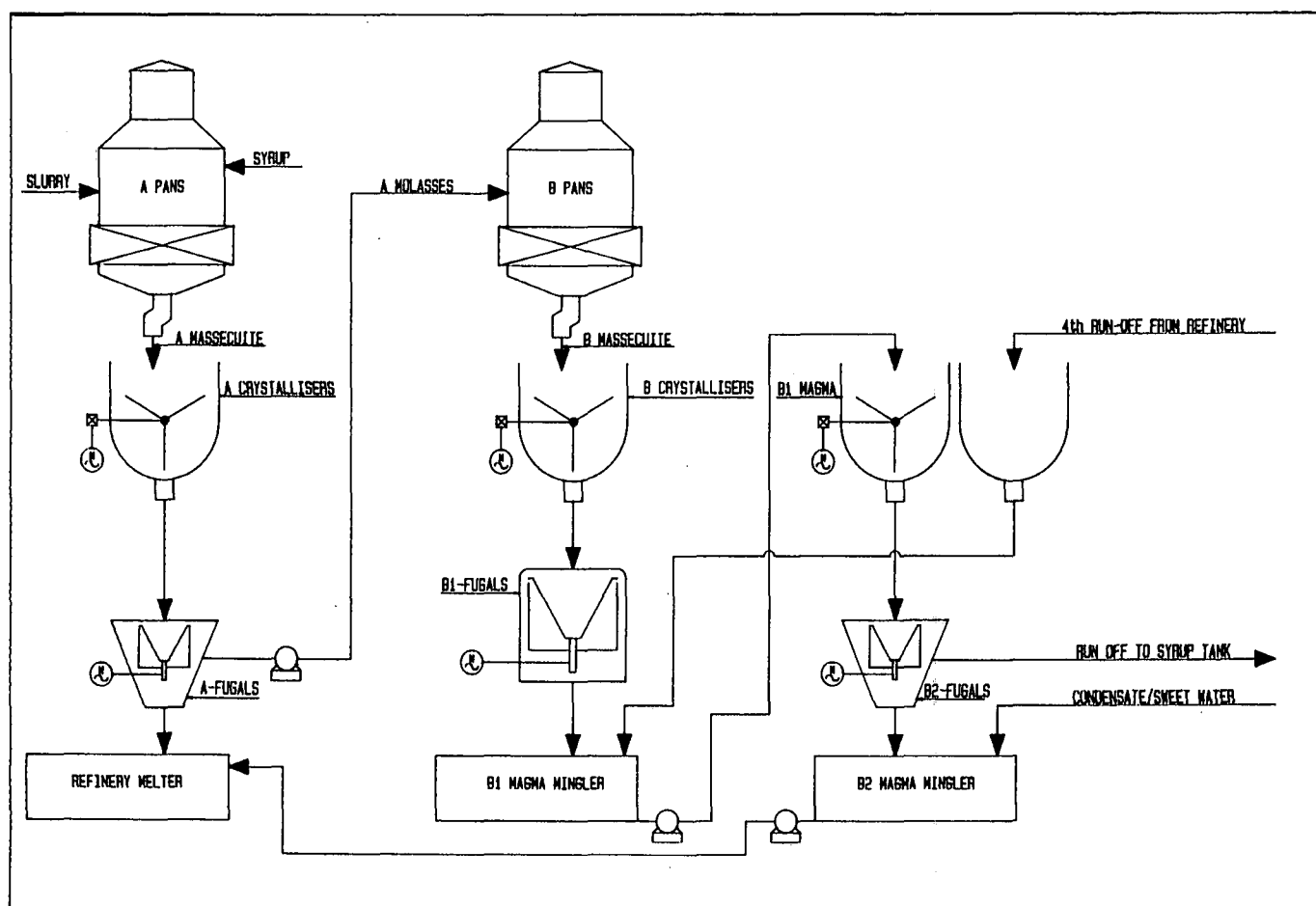


FIGURE 1B Affination flow diagram.

To accommodate the new duty the original 35 degree baskets of the K850 machines were exchanged for baskets with a 30 degree angle and their speed was reduced to 900 rpm. The 30 degree baskets were obtained on an exchange from the Gledhow mill, one of which subsequently had to be returned resulting in a consequently detrimental effect on the B2-sugar quality. The run-off from the B2-centrifugals (termed B-wash, with a purity between 82 and 85) is added to syrup and the B2-sugar is converted to a magma (by using either surplus sweet-water or condensate for mingling) which is then pumped directly to the refinery melter. With all the B-sugar going straight to the refinery the A-pans are slurry-grained. A flow diagram of the process is given in Figure 1.

Results obtained during the 1994 season

It is important to note that NB has been importing significant quantities of raw sugar from the UC sugar mill over the last few years (*i.e.* NB has refined all its own raw sugar and taken in additional amounts ranging from 30 and 80% of its own sugar for refining) and that consequently the direct effect of the affinated B-sugar on factory operations in 1994 is impossible to assess by a straight comparison of the factory data. In many cases the effects have had to be back calculated using the available data.

Sugar quality

The average purity and colour of the affinated B-sugar for the season were 98,9 and 2170 ICUMSA 420 colour units, respectively. In comparison the A-sugar for the season was at 99,7 purity and 1360 colour units. The weekly results of the colours of both the A-sugar and the B2-sugar are shown graphically in Figure 2.

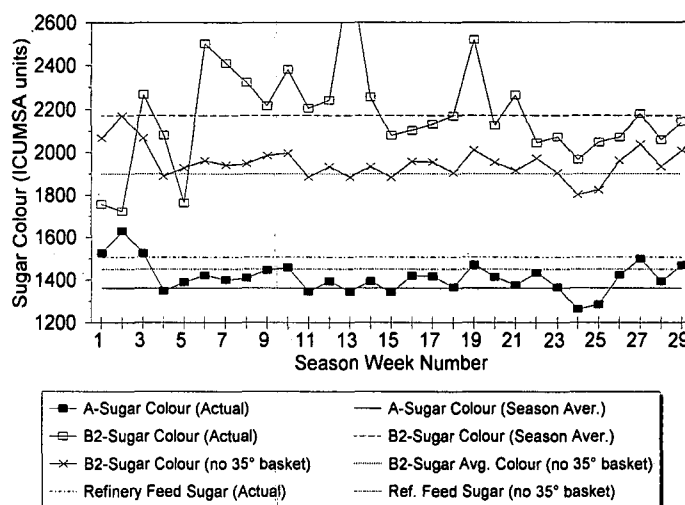


FIGURE 2B Sugar affination - sugar colours.

From the results of the pilot plant tests it was expected that the colour difference between A-sugar and affinated B2-sugar should be around 500 ICUMSA units. The actual difference in colour between these sugars amounted to 810 units during the past season. It is believed that this higher than expected colour difference can be virtually totally accounted for by the poor performance of the affination centrifugal containing the 35° basket. The results of specific tests carried out during the season showed that the centrifugal with the 35° basket produced sugar of 800 units higher colour and 0,3 unit lower purity than did the two centrifugals with the 30° baskets. Assuming this level of performance

difference prevailed the whole season it can be calculated that the average colour of the sugar produced by the centrifugals with the 30° baskets was 1900 ICUMSA units. This is 540 units higher than the A-sugar colour and is only marginally higher than the 500 unit target difference. Figure 2 includes a graphical illustration of these results.

Quantity of massecuite produced

Because of the different quantities of raw sugar imported from UC every season, a calculated correction has had to be applied to the quantities of massecuite reported by NB to bring the data to a comparable basis of zero import. The corrected data for the last four seasons is given in Table 1.

Table 1
A- and B-massecuite volumes at Noodsberg (1991-1994).
(m³ per ton brix in mixed juice)

	Season					% Reduction
	1991	1992	1993	Average (1991-1993)	1994	
A-Massecuite	0,98	1,04	0,96	0,99	0,92	7
B-Massecuite	0,34	0,36	0,33	0,34	0,30	12

Compared with the average quantities of the previous three seasons the reduction in massecuite production was 7 and 12 percent for the A- and B- massecuites, respectively. This reduction, although quite substantial, is about half lower than the expected theoretical reduction of 15 and 21%.

Steam saving

Because the reduction in A- and B- massecuites was only half of the theoretical expectation (1,6 points in steam % cane) it is estimated that the steam saving for the 1994 season has been about 0,8 point in steam % cane. This saving is equivalent to a coal saving of about 2000 tons during the last season. Webb and Koster (1991) in a review of energy management improvements at Noodsberg determined that steam on cane should average 53,0% whereas the actual measured figure for the past season was 51,5% which represents a 2,5 percentage point improvement. Although many other factors and possibly even measurement errors could have contributed to this, it is believed that the 0,8 point improvement is very possibly understated.

Cost of refining

Ignoring the sugar imported from UC it is calculated that the refinery feed from the NB mill only was made up of 82% A-sugar and 18% B-sugar. Based on the average colour of the A- and B-sugars reported above the colour of the refinery feed in 1994 was 1506 units compared with the colour of 1360 had it been A-sugar only. This is a colour increase of 10%. It is estimated that the elimination of the poorly performing 35% basket would have reduced the feed colour to about 1450 (i.e. giving an increase in the colour of refinery feed of less than 7%). This information is also portrayed graphically in Figure 2.

The cost of refinery chemicals, which are affected by changes in raw sugar quality, amounts to R3,59 per ton of refined sugar at NB. Assuming that the cost of refining chemicals varies directly with the colour input the additional cost attributable to B-affination would be about 36 cents per ton refined for 1994 (it would be reduced to around 25 cents with an additional 30 degree basket).

The financial implications of B-affination

Based on the results obtained in this first year of operation, which it is felt could be markedly improved by optimisation in certain areas of operation, the savings in equipment and operational costs are as summarised below. The data is applicable to a 300 tons cane per hour mill-cum-refinery producing 160 000 tonnes of refined sugar annually.

Capital equipment

The reduced equipment requirements brought about by B-affination represents a potential capital equipment saving. This will, of course, only be realised when a new plant is erected or an expansion programme is started on. It has been determined that, based on the results actually achieved so far, the savings detailed below could be realised.

A/B-pan capacity reduction - 24 m³ @ R30 000/m³ = R 720 000
A/B-crystalliser capacity - 43 m³ @ R 9 000/m³ = R 387 000
A-centrifugal capacity - = R 250 000
Total "capital" saving = R1 357 000

Note that, because of the double curing required for B-affination, no change in B-centrifugal capacity has been allowed, in spite of the reduction in the quantity of B-massecuite. It should further be noted that NB has also achieved a reduction in 180 m³ of B-crystalliser usage through curing "hot" B-massecuite.

The "capital" savings must be off-set against the capital expenditure incurred to instal the B-affination facilities. At NB the additional equipment amounted to very little; "big" casings were fitted around the three fore-curers and four additional pumps were installed with some piping alterations (the approximate cost of which was R200 000).

Operational costs

The two main operational costs which are affected by B-affination are the steam consumption and the usage of refinery chemicals. The annual cost savings and increases for these are detailed below.

Saving in steam (coal equivalent):
2000 tons coal @ R120 per ton = R240 000
less
Additional cost of refinery chemicals:
160 000 tons refined sugar @ R0,36 per ton = R 57 600
Nett annual saving in operational costs = R182 400

An important aspect of B-affination is its expected positive influence on the overall sucrose recovery through the reduction in massecuite boiling and sucrose recirculation. However the improvement is extremely difficult to assess and its financial benefits are ignored in this report.

Discussion

Brix throughput

As has been mentioned earlier, the A- and B-crystallisation stations at NB have been capacity constraining sections of the factory for a number of years. It has been determined, through practical experience, that the maximum brix throughput which could be sustained for any reasonable duration was 48 tons/hour in mixed juice. Even then maintaining this throughput rate was dependent on having a high purity, low viscosity product and curtailing the extent of the refinery returns to the raw house. During the past season a

mixed juice brix throughput rate of 48 tons/hour was able to be sustained very comfortably, even with very high viscosity products. Although the situation did not arise where higher throughputs were required for any extended period, it is believed that a sustained rate in excess of 50 tons per hour of brix in mixed juice could now be handled, even with adverse cane quality and that with good (low viscosity) cane quality this would increase to 52 tons/hour.

Back-end full stops

Because of the capacity limitations mentioned above, back-end full production stoppages had become a feature of NB's operation, particularly during the difficult end-of-season period. The total hours of back-end full stops recorded during each month of crushing for the past five years is given in Table 2. Although 3,76 hours of stops have been booked during the past (1994/95) season, these arose from three mechanical breakdowns which affected the evaporator station resulting in "slack" syrup being the cause of the stop. Therefore there were no stoppages due to A- and B-station capacity problems last season.

Refined sugar quality

A very important consideration, when evaluating B-sugar affination, is to establish that there has not been any adverse effects on refined sugar quality. The average colour of the refined sugar made last season was 43 ICUMSA 420 colour units, with the turbidity and suspended solid levels also being, at all times, well below those specified. It can therefore be concluded that there was no negative effect on the refined sugar quality arising from B-affination.

Other operational considerations

As is typical with a new project of this nature there were numerous operational problems that had (and in some cases still have) to be resolved. Some of these included obtaining the correct wash-water spray configuration, maintaining the correct consistency of both the B1- and B2-magmas and producing the optimum B-sugar crystal size.

Slurry graining of the A-masseccuite created some minor problems. A slight loss in efficiency of pan utilisation (when compared with using magma as a footing) was more than off-set by the overall gains achieved. The NB A-pan station consists of three 45 m³ and one 65 m³ pan which has always created a slight problem with maintaining the same grain size in all strikes. This problem arises from often having to split an uneven fraction of an A-seed between the larger and smaller pans during "cutting" operations, it is felt that slurry graining makes this a little more difficult.

A spin-off of the facilities set up for B-affination is the opportunity this has created to use the affination centrifugals for curing "recovery" house masseccuites during the out-of-season refining exercises that NB has been required to start. If this facility was not available the batch A-centrifugals would have to be used, with the drawback that the machines

would be grossly oversized for the duty thereby accentuating the inherent disadvantages of these machines (*i.e.* high power consumption, unsteady electrical load etc.).

Further developments

A logical development from B-affination is to try to use C-magma for a footing for A-masseccuite. This was attempted on two occasions during the past season but was unsuccessful because a sufficiently good quality (even sized) crystal population could not be obtained. However, the idea has not been abandoned and further testing is planned.

Much has been mentioned about the poor performance of the 35 degree basket relative to the two of 30 degrees. Greig *et al.* (1992) have also reported that significantly better affination performance was achieved with the use of a centrifugal fitted with a 25 degree basket when compared with those with a 30 degree angle. This therefore seems to be an important aspect to be investigated in attempts to optimise the process.

Conclusions

The first year of operation of B-affination at NB was most encouraging and the performance confirmed that it is a practical and cost effective process for a back-end refinery. However, the results obtained were not as good as can be expected and more attention towards optimising the station will be needed before its full potential is realised. Two obvious areas of attention are the replacement of the 35 degree basket and the production of a larger B-crystal.

Acknowledgements

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Table 2

Hours of back-end full stoppages (1990-1994)

Season	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1990/91	0,00	8,60	0,00	0,93	1,20	0,00	1,59	-	12,31
1991/92	1,10	0,00	0,00	0,00	3,10	12,20	41,07	4,93	62,40
1992/93	-	9,15	1,00	2,33	4,37	1,45	3,08	4,08	25,47
1993/94	-	5,15	2,93	8,23	10,47	7,95	-	-	34,73
1994/95	-	1,58	2,18	0,00	0,00	0,00	0,00	0,00	3,76