SOME FACTORS CONTRIBUTING TO THE IMPROVED BOILING HOUSE PERFORMANCE AT MHLUME

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Abstract

The performance of the Mhlume boiling house has improved significantly over the past five seasons. Some of the factors contributing to this improvement are discussed in detail. These include steps taken to maximize A-exhaustion and to reduce final molasses purity and hence molasses loss. Also discussed are the efforts to reduce both the cake loss and the clear juice-filtrate purity difference. Some of the attempts to reduce undetermined losses are mentioned. Graphs depicting trends over the past ten seasons for these and other parameters are shown. The importance of producing a good quality crystal is emphasized.

Introduction

Mhlume crushes some 300 tons of cane per hour, equally divided between a 1675 mm, 6 mill tandem and a BMA diffuser. Diffuser juice is clarified in a 7,3 m diameter SRI clarifier and the mill juice together with all filtrate in a 9,1 m RapiDorr clarifier. Hot liming is practised in both cases. The evaporator station consists of three sets of evaporators, one quadruple effect of 6880 m^2 heating surface and two quadruple/quintuple effects of 3110 and 2275 m^2 heating surface respectively. This front-end configuration allows for cleaning half the heating surface every week while hammers and knives are being changed on the diffuser and mill. The plant is totally shut down only every 6 to 8 weeks.

The pan floor consists of 6 A pans of 250 m^3 total capacity, 4 B pans of 120 m^3 total capacity and 2 C pans of 100 m^3. All crystallisers are operated in series.

The very high pol (VHP) boiling system is employed to manufacture sugar of high pol, i.e. 98,6° Z. All performance figures are based on pol only.

About 93% of the sugar produced in Swaziland is exported and one third of that enjoys preferential pricing under the LOME agreement. Cane payment is according to the Direct Analysis of Cane system and is the responsibility of the factory laboratory. The Swaziland industry employs an inspecting technologist to visit factories regularly to verify cane testing results.

Recent trends in boiling house recovery

It is evident from Figure 1 that pol boiling house recovery has improved significantly in recent years from a ten-year low of 88,23 for the 1983/84 season to an all time high of 92,92 in 1988/89. Performance compares favourably with southern African factories reporting to the Sugar Milling Research Institute (SMRI) in that for three of the past five seasons, the (pol based) recovery was the highest recorded in the industry and for the other two years was second best to neighbouring Simunye.

It will also be noticed from the graph that the mixed juice apparent purity has remained in the region of 85%, allowing for seasonal fluctuations, throughout this period. The BHR trend followed that of mixed juice purity closely until 1984, whereupon BHR started to show a significant increase in relation to juice purity.

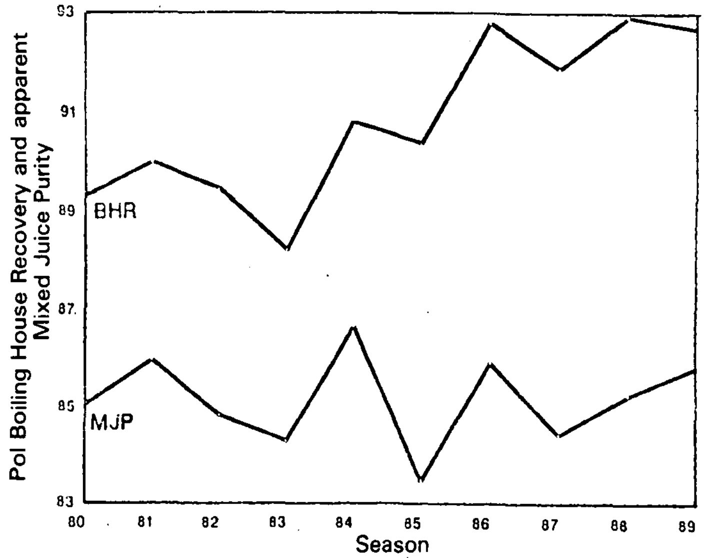

FIGURE 1 Boiling house recovery and mixed juice apparent purity from 1980 to 1989.

Factors contributing to the improved recovery

Increased A-exhaustion

The A-exhaustion at Mhlume for the period 1980 to 1985 can be considered as acceptable for a raw sugar factory operating under southern African conditions. The positive effects of good A-exhaustion are well documented. Jullienne as far back as 1976[2] and again in 1984[3] emphasized the importance of high grade exhaustion. It was therefore decided to pursue a policy of maximization of A-exhaustion performance and the results of this are clearly indicated in Figure 2.

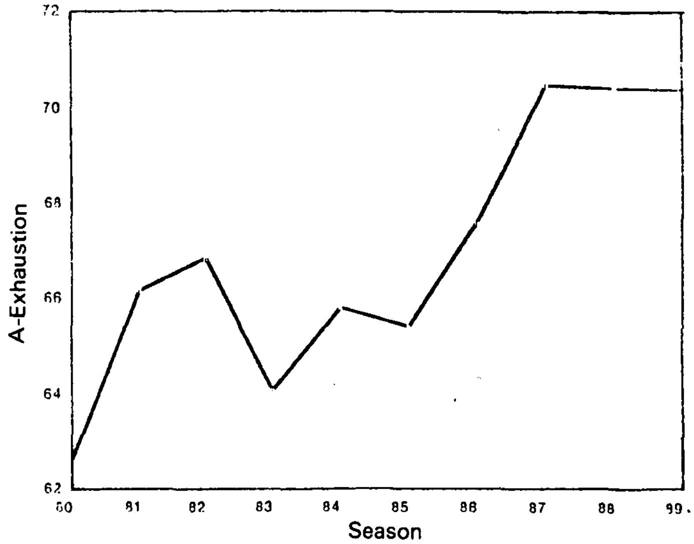

FIGURE 2 A-massecuite exhaustion from 1980 to 1989.

Following are some factors contributing to the good A-exhaustion as well as some of the steps taken to improve the performance thereof.

Boiling system: There is no question that Mhlume does benefit from having a lower sugar pol standard than South African factories, but to precisely what extent is uncertain. What is certain is that the benefit of the lower standard is to be found in A-exhaustion, since less water washing is needed in the A-centrifugals (in practice 1% on massecuite) to attain the required 98,6° Z sugar, which obviously results in a lower A-molasses purity.

Despite the lower sugar pol standard, the VHP boiling system as generally applied in South Africa is used, that i.e. all single cured C-sugar is remelted and B-magma is used as a footing for A-massecuite. Any excess B-magma is remelted. Facilities did exist to use a double magma system; but these have been eliminated in the belief that any gain in steam economy is largely offset by a decrease in A-exhaustion, due to the additional wash water required at the A-centrifugals in order to achieve the desired sugar pol. Since the VHP boiling system was designed to achieve high quality crystal, by applying it to meet HP standards a significant improvement in A-exhaustion must occur.

Of interest is the fact that the average imbibition % fibre for the five years up to and including 1984 was 308% and the average fcr the five years since then 391%, despite the use of the VHP system.

Massecuite quality: The positive effects of high massecuite brix on exhaustion are well known. The target for A-massecuite brix at Mhlume is 93° Bx minimum with a target pan discharge time of ten minutes. While it is acknowledged that colour transfer increases with an increase in massecuite brix, this is not a problem at Mhlume due to the lower quality standards. The crystal content of the massecuite has significantly improved recently as seen in Figure 3.

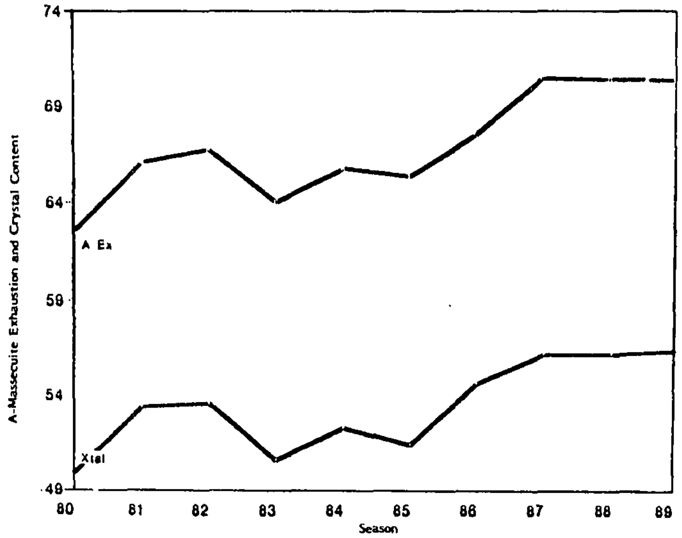

FIGURE 3 A-massecuite exhaustion and A-massecuite crystal content from 1980 to 1989.

Specific grain size has been maintained at 0,7 mm since 1987 before which 0,65 was the norm. Mean aperture is around 0,85 mm with a coefficient of variation of 30%.

False grain is not tolerated and any occurrence results in disciplinary action against the individual concerned. The pan floor supervisor is responsible for carrying out regular quality checks.

Since a high crystal content in massecuite is commensurate with a high exhaustion, and assuming that no more than the usual damage is done in the centrifugals, then, for a given sugar quality, recovery must improve with an increase in A-exhaustion. After all, recovery is all about the physical removal of crystal from the process stream. The fact that the crystal consists mostly of pol merely provides for a convenient measure of performance.

Pan Boiler training: In order to achieve the desired massecuite quality, it follows that pan boiling must be consistently of a high standard. Mhlume is fortunate in this regard because pan boiling is a recognized trade in Swaziland. Trainees serve a five year apprenticeship which includes:

- A one year mechanical skills course (City and Guilds 820) which includes elementary fitting and welding. This is usually started sometime during the first year.
- The two week pan boiling course at the South African Sugar Industry Training Centre at Mount Edgecombe.
- Further in-house theoretical training with particular emphasis on the required massecuite quality.

Practical training consists of boiling one grade of pan for a season for second to fourth year apprentices. During the fifth year, trainees will spend about a month at the other two sugar mills in Swaziland to acquire wider experience. During off crop, their mechanical skills are utilized and developed. Practical training is carried out under the guidance of the process foreman, himself a qualified pan boiler. Much emphasis is placed on instilling a sense of pride in the trainee's work. This scheme has resulted in a well motivated pan boiling staff committed to achieving excellent results.

4 A-centrifugals

Prior to the 1987/88 season the A-centrifugal station consisted of 12 manually ploughed, semi-automatic machines, five of which required manual washing. The purity rise across these machines varied between four and eight units with an average of five. These results were obviously having an adverse effect on A-exhaustion and led to a decision to replace them with the modern fully automatic type. Based on the experience at Union Co-op (Currie[1]), it was decided to purchase four BMA G1500 centrifugals. The installing of these machines has had the most significant effect on exhaustion as can be clearly seen in Figure 3. The purity rise across the A-centrifugals now varies between one and two units. Perforated screens of 18% open area and 0,55 mm diameter holes are used.

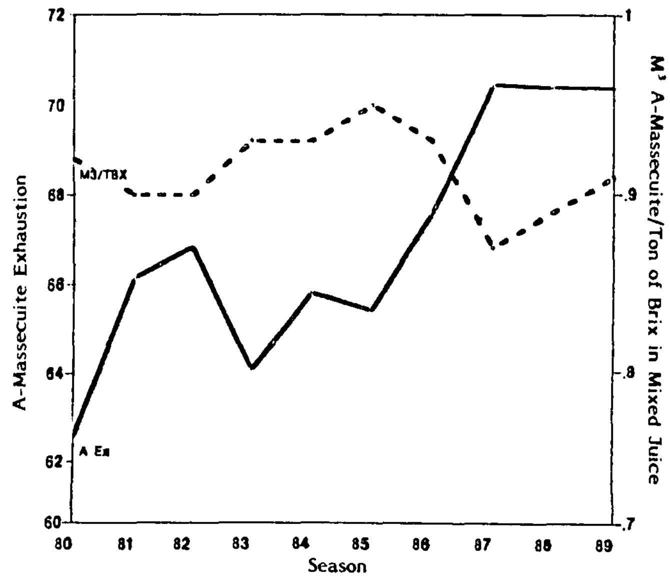

FIGURE 4 A-massecuite exhaustion and A-massecuite volume from 1980 to 1989. Note that the 1989 massecuite volume figure ha adjusted due to changes in volume measurement.

Massecuite Volume

Figure 4 shows the trends of A-exhaustion and A-massecuite volume for the past ten seasons.

It is interesting to note that the curves are almost mirror images which confirms the fact that A-massecuite volume will decrease with an increase in A-exhaustion. A correlation coefficient of −0,69 was found. The correlation between A-exhaustion and volume of other massecuites is shown in Table 1.

Table 1

Correlation coefficients between A-exhaustion and various massecuite volumes (10 year average)

A-massecuite	−0,69
B-massecuite	−0,26
C-massecuite	0,09
Total massecuite	−0,50

It is interesting to note that the increase in A-exhaustion has had no effect on C-massecuite volume.

Before ending the discussion on A-exhaustion it is pertinent to show that of the B- and C-massecuites as well (see Table 2).

Table 2

A, B and C-massecuite exhaustion from 1980 to 1989

Season	A	B	C
1980/81	62,59	61,09	46,89
1981/82	66,15	61,34	55,03
1982/83	66,82	61,08	48,67
1983/84	64,07	62,92	54,80
1984/85	65,80	62,19	53,83
1985/86	65,41	62,69	60,14
1986/87	67,57	66,22	63,64
1987/88	70,48	65,03	62,40
1988/89	70,41	65,91	61,79
1989/90	70,39	66,52	60,68

Reduced molasses loss

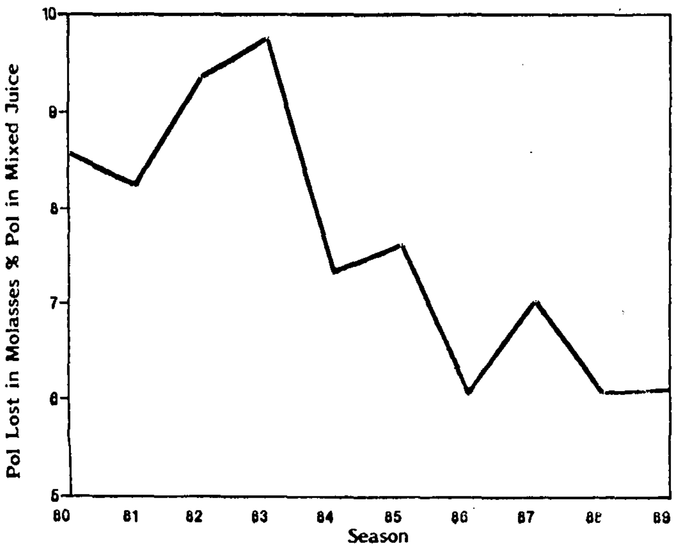

FIGURE 5 Pol lost in final molasses % pol in mixed juice from 1980 to 1989

Molasses % cane, as can be expected, has fluctuated in sympathy with the seasonal changes in mixed juice purity (see Figure 5). The significant reduction in molasses loss is therefore due to the marked decrease in molasses purity. The pol/refractometer brix purity has been the lowest reported in southern Africa for the past 5 seasons despite the fact the Mhlume has the lowest installed C-centrifugal capacity in the region.

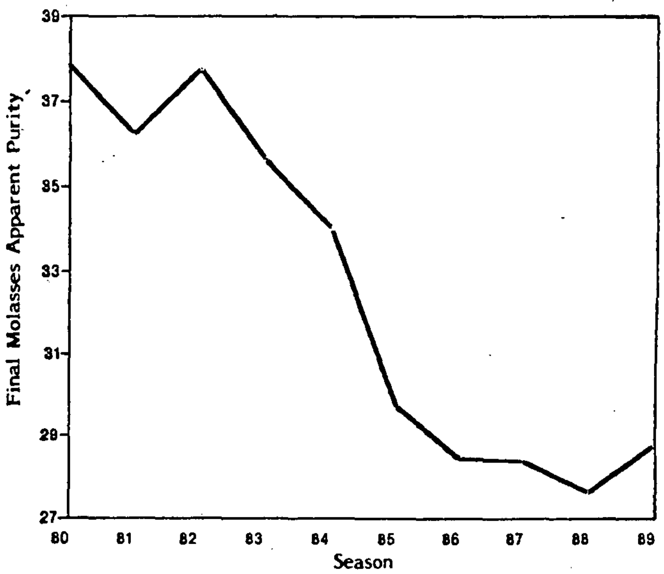

FIGURE 6 Final Molasses apparent purity from 1980 to 1989

Figure 6 shows that molasses purity has "bottomed out" and that further improvements will be difficult to obtain with existing equipment.

Target purity difference is determined monthly on a composite sample by the SMRI using the old Lane and Eynon total invert titration method (Figure 7). This is based on the old SMRI formula and is not the same as the GC based target purity difference reported for South African mills. Typical results vary from +1,0 for May to −2,5 for August/September. The best recorded was −3,5 in July 1986. This sample was also analysed by the gas chromatography method by the SMRI with a result of −0,8. The value of TPD is believed to be an indication that molasses purity is acceptable or not and is not perceived to be a performance parameter of major importance.

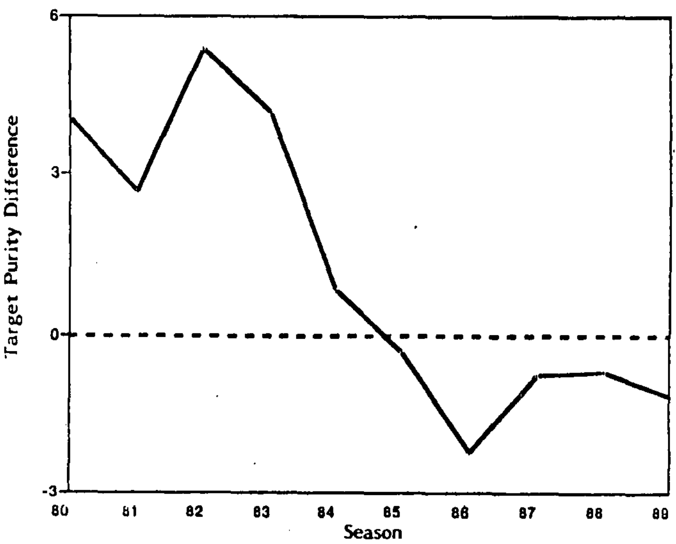

FIGURE 7 Weighted average target purity difference (Eynon and Lane Method) from 1980 to 1989.

C-Pan boiling: As with A-boilings, much emphasis is placed on crystal quality. Jullienne[4] showed that crystal size distribution has a strong influence on centrifugal losses. With this in mind, from 1985 onwards, seeding (without the aid of instruments at this stage) has been done on a mixture of syrup and A-molasses at a purity of between 75 and 80, depending on the time of the season. This high purity has been found to provide a good crop of well shaped crystals and is believed to be essential in producing a good quality massecuite. Sufficient slurry is used to obtain a crystal width of 160 microns in the final massecuite. The target for percentage by mass less that 120 microns is 6% and is usually achieved. C-massecuite purity is adjusted according to the time of the season from around 48 in May to 53 in November. This has been found from experience to provide maximum exhaustion without compromising factory liquor stock levels or throughput of the C-centrifugals. See Table 2 for C-exhaustion performance.

The only instrumentation on the pans during 1984 was absolute pressure control. An old disused SUMA conductivity indicator was resurrected and C-massecuite purity was decreased to slightly above 52 and an immediate improvement in massecuite quality was apparent. At the same time, a rigorous inspection program for C-centrifugal screens was introduced which also contributed to the decline in final molasses purity. During 1985 a Calcor Auto-pan conductivity controller was installed with a further improvement in results. The purity drop between massecuite and strike nutsch averages around 17 units.

Crystallizer work: The C-crystallizer stations at Mhlume consists of 7 x 65 m^3 Blanchard type water cooled crystallizers connected in series. This provides a retention time in the region of 52 hours. The temperature decreases across the crystallizers from 66°C t 40°C. The resulting purity drop varies from 6 to 8 with an average of slightly more than 7 units.

Massecuite is reheated to as low a temperature as possible depending on the prevailing viscosity. Reheated massecuite temperature varies between 46 and 54°C. Nutsch purity increase across the reheater is usually less than 0,5 units.

Centrifugal work: As already mentioned, the C-centrifugal station has the lowest installed capacity in Southern Africa. According to Lamusse,[5] as published in Table K in the review of the 1988-1989 season, the installed C-centrifugal capacity at Mhlume is only some 66% of the South African average. Throughput per machine varies between 1,65 and 2,6 tons of massecuite per hour with the higher value occurring at the beginning of the season.

This has lead to much attention being paid to the efficient operation of these machines, particularly at the beginning of a season when juice purity is low. A rigorous visual inspection program was instituted from 1984 to ensure that any installed screen is in good condition. Screen working life was approximately seven weeks until mid 1989 but, since changing to the locally manufactured screens, this has improved to about 9 weeks per screen which, if this performance is maintained, should result in substantial financial savings. Presently, screens of 10% open area with 0,06 x 2,8 mm slots are used.

Target C-sugar purity is mixed juice purity or 82, whichever is the lower. Purity rise across the machines is around 1 unit.

Viscosity: It is firmly believed that the main reason that C-station performance has been as good as it has is the fact that the cane crushed at Mhlume is fresh (by South African standards) and because of the extensive use of irrigation and chemical ripeners is generally of good quality. It is believed that this results in low viscosity in the back-end which is of much benefit, not only in terms of throughput, but also in terms of improved crystallization. The average burn-to-crush delay for the mill group as a whole is 54 hours. The delay for bin delivered cane (47% of total) is significantly less at 33 hours.

During periods when delays are excessive, for example following heavy rains, and there is a marked increase in viscosity as indicated by crystallizer amperage, C-massecuite purity is increased by 2 to 3 units and sodium hydrosulphite is dosed at the rate of 1 kg per 10 m^3 of massecuite in the C-pans to enable throughput to be maintained.

Any further improvement in final molasses figures is unlikely with existing equipment.

Reduced cake loss

Cake loss for the past 10 seasons is shown in Figure 8. Since filter cake % cane has remained at more or less the same level of 2,5% over the years, the reason for the improvement in cake loss is the significant reduction in pol % cake. Lionnet[6,7] in 1984 proposed a fundamental change in vacuum filter operating technique. These and other changes to plant have been gradually introduced at Mhlume over the past 5 seasons with benefits not only to pol % cake but also to the clear juice-filtrate purity difference.

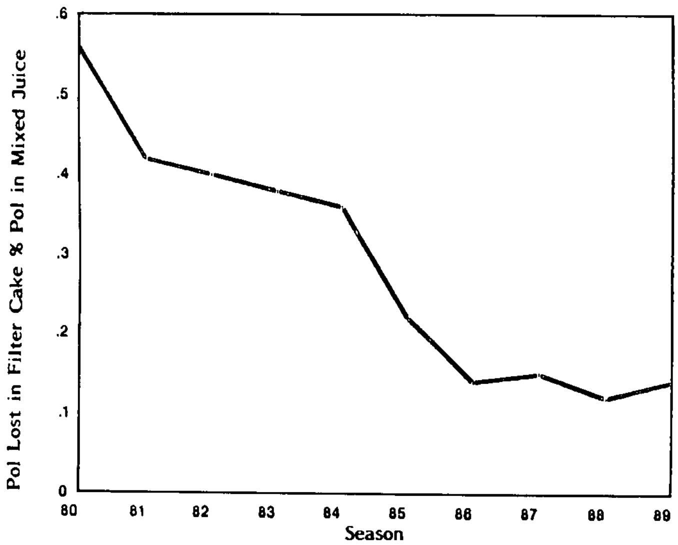

FIGURE 8 Pol lost in filter cake % pol in mixed juice

Only 3 parameters are believed to be of importance for good filter operation. These are pol % cake, clear juice-filtrate purity difference and filtrate pH. These are the only routine analyses carried out by the laboratory. Any marked deviation from typical values obviously gives rise to closer investigation. These values are improved over a 10 year period as shown in Figure 9.

Some of the steps taken were:–

- During 1984 investigations showed that filtrate pumps were in poor condition and the wash water supply was inadequate. These were replaced before the start of the next season. During 1985, the mud level control system on the mud mixer and filters was modified in at attempt to prevent the overflow of mud from the mixer and the filter troughs. Flocculant at the rate of about 2 ppm was dosed into mud. These steps reduced the pol % cake from 1,9 to 1.19% and the clear juice-filtrate purity difference from 3,9 t 2,4

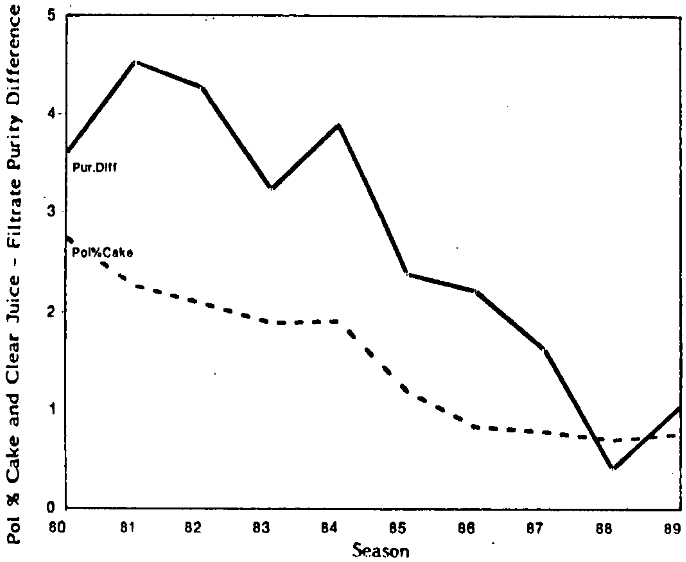

FIGURE 9 Pol % filter cake and clear juice – filtrate purity difference from 1980 to 1989

- Before the start of the 1986 season a large section of filtrate and vacuum piping was renewed, and the filtrate receivers were replaced to eliminate air leaks and some minor modifications were made to the diffuser bagacillo screens. It was also decided to implement fully the operational philosophy as advocated by Lionnet.[6,7] To this effect, mud solids were reduced to about 3,5 to 4% on feed, lime was added to mud so that the filtrate pH was kept between 6,9 and 7,2 and steam spargers were installed in the filter troughs and the mud mixer to heat the mud to above 80°C. The results of these efforts were pleasing in that pol % cake decreased to 0,83; the first time that a figure below 1% had been achieved. Pol % cake has remained below 1% since then, and no further improvement can be expected with the existing equipment. The clear juice filtrate purity difference result was however still a disappointing 2,2
- Prior to the 1987 season most of the mud piping was lagged and this resulted in a decrease in the purity drop to 1,6. A small section of approximately 6 m of piping at the outlet of the SRI clarifier was lagged before the start of the 1988 season with remarkable results, in that the purity difference decreased to only 0,4. Unfortunately a serious problem with the vacuum pump as well as the filter cake conveyor chain prevented a repeat of this performance during 1989.

Undetermined loss

Figure 10 traces the undetermined loss for the past 10 seasons. The loss prior to 1985 must be viewed with some circumspection since molasses production (and hence undetermined loss) was calculated by measuring molasses storage tank wantage. After the molasses scale was repaired, it became evident that Mhlume did have an undetermined loss problem. Some efforts to contain undetermined losses have been:

- During 1986 a trend emerged which indicated an increase in undetermined loss whenever sugar was being bagged. Intense investigation uncovered theft involving a significant quantity of sugar
- Two of the evaporator final effects were known to be contributing to the high sugar traces of around 100 ppm in condenser cooling water. To overcome this problem, the height of the body of one was raised by 1,2 m and a Poly-Baffle entrainment arrestor was installed on the other (1987). These steps proved to be most successful in that sugar traces immediately reduced to a more acceptable 10 to 15 ppm
- Effluent losses have been measured by means of a proportional sampler since 1986, and average loss is between 500 and 1000 kg per week
- The cause of the increase in undetermined loss in 1989 is unknown but the undetermined loss was nevertheless still the third best result in the industry.

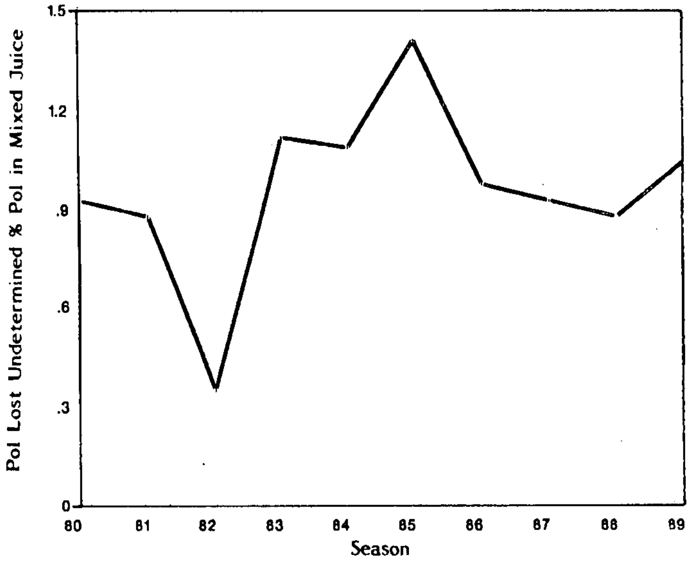

FIGURE 10 Pol lost undetermined % pol in mixed juice from 1980 to 1989.

Conclusions

The improvement in BHR at Mhlume can largely be attributed to the application of the findings of Jullienne with regard to the maximisation of A-exhaustion and in particular the attention to A- and C-crystal quality and to those of Lionnet with regard to mud treatment and vacuum filter operation.

Use of the VHP system in producing HP sugar at Mhlume has benefited A-exhaustion without detriment to steam economy.

Acknowledgements

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REFERENCES

1. Currie, AF (1986). Experiences with the BMA G1500 centrifugal on A-massecuite. *Proc S Afr Sug Technol Ass* 60: 43-46.
2. Jullienne, LMSA (1976). "A" massecuite exhaustion and low purity "C" massecuite at Melville. *Proc S Afr Sug Technol Ass* 50: 194-197.
3. Jullienne, LMSA (1984). Exhaustion and colour investigations in A-massecuite. *Proc S Afr Sug Technol Ass* 58: 42-46.
4. Jullienne, LMSA (1985). South African C-massecuites: crystal size distribution and its effect on centrifugal losses. *Proc S Afr Sug Technol Ass* 59: 79-82.
5. Lamusse, JP (1989). Sixty-fourth annual review of the milling season in Southern Africa (1988-1989). *Proc S Afr Sug Technol Ass* 63: 7-27.
6. Lionnet, GRE (1984). Mud conditioning for good filter operation. *Proc S Afr Sug Technol Ass* 58: 39-41.
7. Lionnet, GRE (1984). Notes on the operation of rotary vacuum filters. *Sugar Milling Research Institute Technical Note* No. 3.