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FILTER STATION PERFORMANCE IMPROVEMENTS AT NOODSBERG

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Abstract

The installation of a new bagacillo collection and handling system at Noodsberg has led to a substantial improvement in performance of the whole filter station. This new system also provided the spur for implementing other means of improving the filter station performance, amongst which was the use of transducers developed by the Sugar Milling Research Institute for measuring and controlling filter feed consistency and for measuring turbidity (of the filtrate). Details of the design and operation of the new bagacillo system and the performance of the new transducers and the consequent impact all these changes have had on the overall filter station performance are given. The improvements achieved resulted in a direct reduction in loss of sucrose in filter cake (as % sucrose in cane) from a previous five year average of 0,52% to a level of 0,31% and translates into a saving of R405 000 in loss of sugar during the past season.

Introduction

For the past several seasons the suspended solids content of the mixed juice at Noodsberg (NB) has been the highest in the industry by a quite substantial margin (five year average suspended solids % mixed juice: industry average = 0,34; NB = 1,06). This arises from a combination of the fact that NB has one of the few remaining milling tandems in the industry and that even among milling factories (as opposed to diffusion factories) the cane processed at NB gives an abnormally high level of suspended solids in the extracted juice. This in turn means that the quantity of filter cake produced by NB is the highest in the industry (five year average filter cake % cane: industry average 3,22; NB 6,15). Therefore ensuring the filter station performs well is more critical for NB than for any other factory in the industry.

In addition, the bagacillo handling plant provided for collection of bagacillo close to the mills away from any recirculated bagasse, and contained only a very limited buffer storage capacity. Therefore any mill stop longer than five minutes resulted in the filter station running out of bagacillo and necessitated the shutting down of the filters. The consequence of this was increased pol % filter cake due to the erratic operation of the station, particularly during the times the filters were being started and stopped. It also meant that controlling the mud levels in the clarifiers, especially during rainy periods, was always very difficult and probably resulted in significant deterioration occurring in stagnant mud. This effect would have been particularly pronounced during long mill stops because of the inability to empty the mud from the clarifier.

Upgrading of the bagacillo handling system

At the end of the 1993/94 milling season the bagacillo separation and handling system at NB had reached a stage where extensive refurbishing was required due to cumulative damage from corrosion and erosion. The repairs required included replacement of major sections of the ducting, complete renewal of one cyclone, renewal of a bagacillo collection hopper and replacement of several worn and eroded screens.

It was therefore decided to take the opportunity to design a new station to remove the inherent disadvantages of the old system. A "kicker-type" pneumatic collection system instead of the perforated plate screens of the old plant was chosen because of its simplicity of design, ease of operation, compactness, and lower installation and maintenance costs. It also reportedly provided a better and easier control over the quantity and quality (fineness) of the bagacillo obtained (Cullen, 1967 and Hoareau, 1974).

Prior to the 1993/94 season a system of this design had not been used in South Africa. A pneumatic bagacillo separator of this type was used for the first time in South Africa during the 1993/94 crushing season at Umfolozi (van Duyker *et al.*, 1994). The general success of this system gave further encouragement for NB to opt for the same system for its new installation.

Design considerations

Details of some of the more important design considerations are given below.

Quantity of bagacillo required. A wide range of figures for the quantity of bagacillo required for cane mud filtration (in milling factories) are quoted in the literature. These range from 0,3–1,6% bagacillo on cane (Hugot, 1960; Cullen, 1967; North-Coombes, 1974; and Lionnet, 1984). The quantity of bagacillo required for NB was also calculated from actual production figures assuming a peak filter cake production of 7,5% on cane. Assuming typical values for pol %, purity of the residual juice and moisture of filter cake it can then be determined that the combined mud solids and bagacillo content of the filter cake amounts to 25%. Thereafter assuming a bagacillo ratio (ratio between dry weight of fibre to the dry weight of mud solids) of 80 (Lionnet 1984, recommends a range of 75–100%) and further assuming all the mud solids and bagacillo in the filter feed end up in the filter cake the quantity of bagacillo needed for filtration then amounts to 20% of the filter cake or 1,5% on cane. The system was therefore designed for the collection of 4,5 tons of bagacillo an hour, at a 300 tons cane per hour crush rate. Past practical experience and the most recent experience of UF has shown that filter stations often run short of bagacillo during peak cake production periods. Therefore the design for the new NB system was based on peak production requirements and as generous as practical design parameters were adopted throughout.

Quantity of air required. Cullen (1967) uses the concept of material loading (ratio of weight of conveyed material to weight of air) for determining the quantity of air required for conveying the bagacillo from the separator to the mud mixer. He quotes figures in the range 0,15 to 0,3 for material loading. On the other hand North-Coombes* recommends a figure of 0,13 and since this was a more cautious figure it was used. Using this figure and a density of 1,1117 kg/m^3 for ambient air at Noodsberg's altitude (Perry 1984) the

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* S North-Coombes, CG Smith Sugar, private communication, 1990.

volume of air required for transportation amounts to 7,28 m^3/kg of bagacillo or 9,51 m^3/sec.

Ducting, cyclone and fan design. Aerovent Engineering were commissioned to assist with the ducting, fan and cyclone design details. The ducting diameter was determined using an air velocity of 25 m/sec (North-Coombes 1979) and the nearest standard material size of 710 mm O.D. was chosen. The ducting has been constructed from 3 mm 3CR12 (as are the new cyclones). It was determined that two cyclones would be required because the pressure drop in a single cyclone system would be too high necessitating the purchase of a new fan. The cyclones each have an overall height of 7,576 m and a diameter of 1,527 m. From the calculation of the total system pressure drop it was determined that although the existing fan (Atlas Copco, type K, size 26, 14000 CFM, and 1199 rpm) would be adequate it would be necessary to replace the existing 35 kW motor with a more powerfull one and speed up the fan to its design maximum of 1740 rpm. A spare 70 kW motor was installed and although new pulleys were purchased to bring the fan speed up to that recommended, they were not initially installed as it was decided to use these only when peak bagacillo requirement situations were encountered. It was felt that the extra speed would probably not be needed during normal operation and that fan wear and power consumption could be reduced by normally running at the lower speed.

Layout and arrangement of the bagacillo collection system. Fundamental to the new bagacillo handling system was the need to ensure the collection of bagacillo could continue even during extended mill stops. A location was fortunately available which was considered suitably close to the cyclones and which was not only in the path of a permanently supplied bagasse stream but also contained the head space necessary for the separation chamber. A schematic representation of the new system is given in Figure 1.

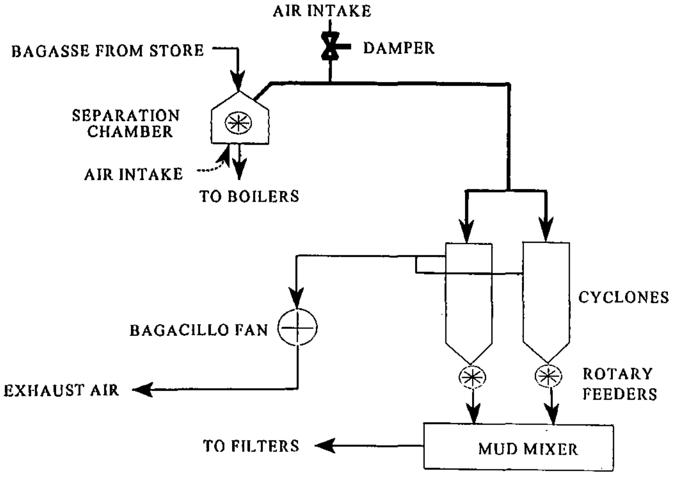

FIGURE 1 Layout of bagacillo handling system.

Design of the bagacillo separation chamber. A schematic representation of the chamber together with some design details are given in Figure 2. The design details of this system were mainly based on information given by Cullen (1967) and where necessary were adapted to fit in with the local constraints. One of these was that although the recommended maximum air velocity in the separation chamber was around 5 m/s a value of around 520 m/s was all that could be achieved because of the lack of space in which to increase the cross-sectional area of the chamber. The reason for this recommendation was based on the reports that the fineness of the bagacillo decreased rapidly with increasing chamber air velocities. Cullen, however, also reported that the degree of bagacillo separation also increased with an increase in air velocity. Based on the premise that was used throughout the design of "quantity first and quality second" it was decided to accept this "apparent" limitation of the NB chamber.

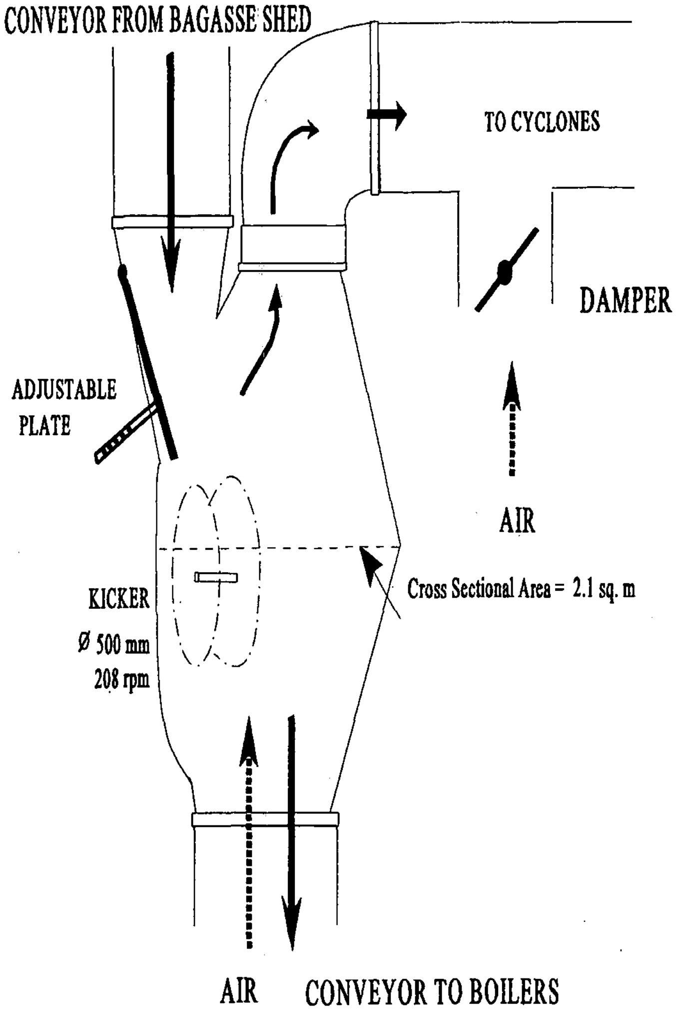

FIGURE 2 Schematic representation of bagacillo separation chamber.

Operation of the new bagacillo system

The new bagacillo system provides three ways for controlling the quantity of bagacillo delivered to the mud mixer. In the first instance two sets of pulleys are available to vary the fan speed, as previously mentioned, between "normal" and "peak" modes. It was not found necessary to use the higher fan speed during the past season. The second option is to vary the angle of the kicker by-pass plate (see Figure 2) so as to expose the kicker to the bagasse stream falling into the chamber either fully, partially or not at all. Adjustments of this type are made infrequently and for most of the past season this plate was adjusted to by-pass the kicker totally.

The last option is the routine operational method used. It consists of manipulating a controller located at the mud-mixer to open or close the damper in the ducting (see Figure 2). With the damper fully closed the total quantity of air is drawn through the separation chamber and the maximum quantity of bagacillo is collected. It was intended that when the damper is fully open the total air flow would be drawn through the damper and none would flow through the chamber. In practice it was discovered that some air flows through the chamber even when the damper is fully open and therefore a small quantity of bagacillo is always collected while the fan is running. The installation of a larger or second damper could overcome this but the problem is considered too insignificant to warrant any action at present.

The normal operating position of the damper was 75-85% open and it is therefore obvious that there is a large surplus capacity in the new system. Given the importance of adequate bagacillo to the operation of a filter station the over design in this system is not considered wasteful. In addition a factor which was not considered in the design of the new system and that has had a strong positive effect on the ability to separate bagacillo from bagasse is the milling performance improvements achieved last season which reduced bagasse moistures from previous levels of around 52% to a range between 46 and 49%.

Bagacillo quality. This is of course a fundamentally important factor for good filter station performance. Lionnet (1984) has reported that the fineness "yardstick" should be that at least 85% by weight should pass through a 0,85 mm screen. Tests conducted at various times during the past season have shown that this figure averaged 90% at NB, with the minimum result obtained being 86%.

Filter station performance improvements

The availability of a high quality, reliable and continuous supply of bagacillo in sufficient quantities that was easy to adjust had an immediate and profound effect on the performance of the NB filter station. Pol % filter cake reduced dramatically and filter retention improved by several points. The operators revelled in the ability to empty the clarifier of mud, so much so, that there was an initial tendency to draw too much mud out of the clarifier, resulting in excessive recirculation of filtrate, which had to be curbed.

Filter feed consistency control

The ability the new system gave to change bagacillo quantities quickly and easily and consequently filter feed consistency and in turn cake thicknesses soon led to the realisation that even better performance could be achieved if this could be automated. It was therefore decided to test the use of a consistency measuring device developed by the Sugar Milling Research Institute (SMRI). The instrument, which has been described by Gooch (1994), is a probe which measures the deflection obtained when the mud mixer stirrer pushes the filter feed mixture against the probe. The degree of deflection obtained is proportional to the consistency of the filter feed mixture and on the installation of this device it was immediately apparent that the measurements were sufficiently sensitive for use as a control signal. It was therefore decided to feed the output signal from this consistency monitoring device to the controller of the bagacillo collection damper, in order to regulate the addition of bagacillo according to a predetermined consistency value. A facility for trending this consistency of the mud/bagacillo mixture was also arranged.

Although this instrument worked well from the start a considerable amount of minor trial and error corrections, involving length, position and other minor aspects of the device, had to be made. In addition it was also discovered that the damper range had to be limited to a minimum of 60% open, otherwise over-shooting of the consistency set point tended to occur, which gave too thick a mixture and which in turn resulted in cake dropping off the filters or a choke somewhere in the system. The consistency of the mud drawn from the clarifier had an obviously significant impact on the performance of the consistency control loop. As long as the clarifier mud consistency was maintained at a reasonably steady level the bagacillo control system worked well and it is believed that the consequent constant operating conditions achieved had a significantly positive effect on the performance of the whole filter station. To make the system completely reliable a logical further development of this system is to use another SMRI developed transducer that uses a venturi system for measuring clarifier mud consistency (Gooch, 1994). The consistency of the mud being fed to the mixer can then be controlled by adjusting the degree of dilution applied.

Filtrate turbidity monitoring

The success of the mud consistency measuring transducer encouraged the use of yet another SMRI developed instrument, this time for measuring juice turbidity. The operation of this device has been described by Stone (1994). It was decided to use this instrument to measure filtrate turbidity, which it proved able to do with an amazing degree of sensitivity. It was found in practice that the filtrate turbidity was very responsive to operational changes made at the filter station and the instrument therefore became an extremely useful tool for optimising performance of the filter station as it gave virtually instant feedback on any operational changes made.

When turbidity measurements were first carried out on the filtrate, typical absorbance values obtained were around 2,4 and subsequent optimisation quickly reduced this to around 1,6 (note that clear juice absorbance values on this instrument will typically be in the range 0,5 to 0,7). Therefore 1,6 became the operator's target norm for filtrate turbidity. When absorbances above this target value were obtained the operators knew some corrective action was required *i.e.* check the filter-feed consistency, check the operating vacuum of the filters (both pick-up and high vacuum values), and maybe also check that the wash water sprays were operating correctly or check for any other abnormality in the system.

In addition to normal operating corrective action the instrument was used to check the benefit of other operational changes. It was found that the addition of flocculant to the mud did give improved filtrate turbidity readings but that the point of addition was important. The optimum position was determined to be close to the mud mixer outlet. Adjusting the top water spray position of the filters to closer to the discharge side in order to reduce water spraying on the pick-up side was also determined to have a beneficial effect on the turbidity reading. A thinner cake was observed to give a marginally better filtrate turbidity. At the end of the season two sets of quick and crude evaluations of the benefits of adding bentonite to the filter feed were made. These tests were of short duration and the bentonite was added as a powder rather than a slurry. The results were however very encouraging with absorbance values of around one being obtained and at one point this dropped to as low as 0,7 (*i.e.* approaching that of clear juice turbidity).

As a final comment it was observed that low filtrate turbidities generally coincided with very good clarity wedge readings for the clear juice being produced at the same time. These clear juice "wedge" readings increased from normal values of around 15 divisions to up to 25 when the filtrate turbidity was particularly low. What is not known is whether the filtrate turbidity was low because the juice quality was good or whether the good quality filtrate gave an improvement to the clear juice quality.

Table 1

Filter station performance parameters (1989/90–1994/95).

Crushing season	Filter cake % cane	Pol % filter cake	Filter retention	CJ-filtrate purity difference	Filter wash index	Sucrose lost in filter cake % sucrose in cane
1989/90	5,51	1,05	93	0,87	108	0,42
1990/91	5,95	1,51	93	0,82	106	0,70
1991/92	5,67	1,37	92	1,02	105	0,58
1992/93	6,50	1,42	88	1,05	104	0,61
1993/94	6,23	1,34	93	0,65	100	0,60
Avg. (1989-1993)	**5,97**	**1,34**	**92**	**0,88**	**105**	**0,58**
1994/95	**6,44**	**0,65**	**95**	**1,05**	**107**	**0,31**

Discussion and performance results

Table 1 gives details of the major filter station performance parameters for the five year period from 1989 to 1993 and compares them with the results achieved in 1994. It can be seen that pol % filter cake has improved by 51% over the past five year average which translates into a 47% reduction in sucrose loss in filter cake. At the same time retention has improved by three percentage points. Although there is a 0,17 unit increase in purity drop between clear juice and filtrate, this is not considered a really significant change since, for the past season, this would correspond to a change in filtrate purity from 84,78 to 84,61 a difference that could easily be attributable to analytical or sampling errors. There is also a slight increase in the filter wash index, which indicates a little more wash water was applied during the past season. Since Noodsberg had a substantial amount of surplus bagasse and no trouble was experienced in attaining the desired syrup brix this is not considered a problem.

The savings attained in reducing the loss of sucrose in filter cake have been estimated to amount to R405 000 for the past season (using the average sugar price paid to millers during the past season). The cost of installing the new bagacillo system totalled R368 000. In evaluating these costs it must be remembered that extensive refurbishing of the old system was required and therefore a substantial portion of these would have been incurred in any case.

Conclusions

A major improvement in the performance of the NB filter station was achieved last season. The new bagacillo handling system provided the main impetus for this. This new station, used in conjunction with instruments developed at the SMRI, has also opened up possibilites for further all round improvements. It is hoped in the coming season to test the venturi type mud consistency transducer to enable virtually full automation of mud withdrawal from the clarifer, dilution and bagacillo addition at the mud mixer. It is expected that this will give benefits in the form of better performance due to the steadier operating conditions and more easily managed plant. It is also planned to extend the measurement of juice turbidity to other streams, *i.e.* cloudy and clear filtrates, mixed juice and clear juice. In this way it is expected that better control over the whole clarification operation and not only the filter station will be achieved. Lastly it is planned to follow up the very promising results obtained with the preliminary bentonite tests with a more extensive evaluation.

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