A PRACTICAL APPROACH TO EVALUATE AND CONTROL SUGAR LOSSES TO THE COOLING TOWER

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Abstract

Carry-over of sugar to the cooling tower is costly and can impact appreciably on undetermined loss. The essence of good factory control is determining the cause of sugar loss at the earliest possible stage. To achieve this areas of concern must be recognised, and levels of contamination must be determined through proper laboratory control methods. In this paper sampling techniques are described, and factory operations likely to be the source of sugar losses to the cooling tower are identified. Practical experience in tracing losses at Umzimkulu mill is related.

Introduction

Any mill that has had sugar carry-over to the cooling tower will know the frustrations in attempting to find the cause of the problem. If one is lucky the problem can be identified and rectified relatively quickly. However, the cause of carry-over is difficult to identify and may take several days to pinpoint. It may also necessitate taking plant off line by having a mill stop or waiting for a weekend shutdown. Either way it is hoped that the cause has been correctly identified, otherwise additional losses will occur after restarting. Umzimkulu experienced a sugar carry-over problem during the 1990 season, which amounted to about 112 tons of sugar. This equalled 0,09 units on the seasonal boiling house recovery (pol). During the investigation all possible areas of contamination were identified and corrected. To facilitate future investigations of this nature, equipment modifications were carried out, sampling and laboratory procedures were streamlined and factory procedures were implemented.

Four key areas that can contribute to sugar losses to the cooling tower are evaporators, pans, filters and crystallisers. These are discussed and are followed by a short description of the Umzimkulu experience. Findings are summarised and conclusions drawn.

Procedures for measuring and monitoring

Sampling

The analysis recommended for an investigation of this nature is the resorcinol/HC1 method, which is accurate to 3 ppm. The method used for sampling condenser water across the evaporator, pan and filter condenser was a continuous drip sample taken every two hours over a 24 hour period. This was necessary to establish a trend.

A consistent difference greater than 50 ppm from condenser water IN to condenser OUT would indicate a severe carry-over problem. (Note: As the condenser should be condensing pure water, the water OUT should be less contaminated than the water IN, which makes any increase in sugar contamination particularly severe.)

Sugar traces of over 100 ppm in cooling tower condenser water were consistently recorded which indicated a severe carry-over of sugar, and an appropriate investigation into the causes was necessary.

Sources of losses investigated

Evaporators

The most likely source of contamination from the evaporators is from the last vessel. The following causes were investigated.

Metex screens

It is possible that the Metex screens were either poorly fitted or may have shifted on the run. To check this, sight glasses with spotlights were fitted above each set of Metex screens which enabled one to visually check whether a screen had shifted. At one stage it was seen that syrup droplets were passing through due to a 'channelling' effect caused by the screens being partially choked. The screens were cleaned and correctly positioned, eliminating the problem.

Vacuum control

Fluctuating absolute pressure control may cause the level of juice in the vessel to rise and fall, thereby causing carry-over . This can be caused by the position of the absolute pressure control valve continuously altering or 'hunting'. The reason for this should be investigated. A likely cause could be leaks in the tailpipe causing the water level to fluctuate in the seal well. These symptoms were noticed at Umzimkulu early in June and contributed to the relatively high losses recorded (weeks 7 to 10 in Figure 1). A crack on the weld of the tailpipe was the cause, but was very difficult to locate due to the inaccessibility of the pipe. Rungs have since been added to give access to the full length of this pipe.

The efficiency of vacuum pumps could also be the cause of fluctuating vacuum. The reason could be water from the condenser flooding the pumps. Sight glasses were installed at the top of the evaporator condenser and on the vacuum line to the pumps, to establish whether water was being carried over to the vacuum pumps. This enabled quick action to be taken to rectify the problem.

The piping from the last effect to the condenser, the evaporator vessel itself, and the condenser could also be likely sources of leaks resulting in poor vacuum control. To check for leaks in these areas the evaporators should be pressurised with vapour and observed for tell-tale wisps of steam. This may be done on a weekend shutdown when the vacuum pumps and condenser water are off line. In this way numerous leaks were found and rectified.

Juice levels

High syrup level in the last vessel may increase the chances of carry-over. This may be due to either poor pump efficiency or blocked screens on the suction to the syrup pumps (especially after weekend cleaning). For easy cleaning the screens were fitted inside a trap pot with a quick release lid. The screens were checked before each weekend start.

Dirty tubes can cause slack syrup due to poor heat transfer and a tendency to operate at high levels. Incondensible gas valves were checked to ensure proper removal of gases to

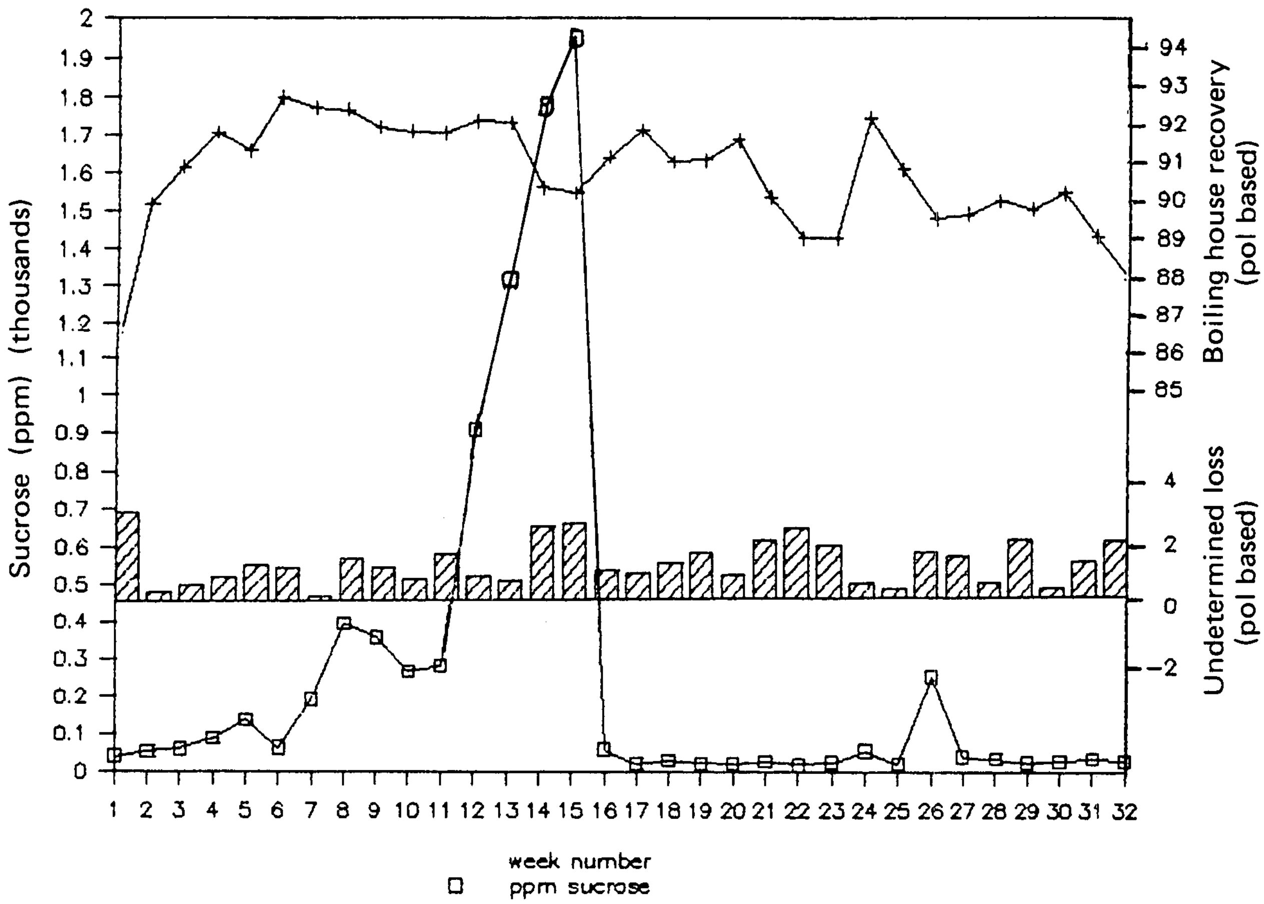

FIGURE 1 The carry-over in weeks 14 and 15 showing the corresponding increase in undetermined pol loss and decrease in boiling house pol recovery.

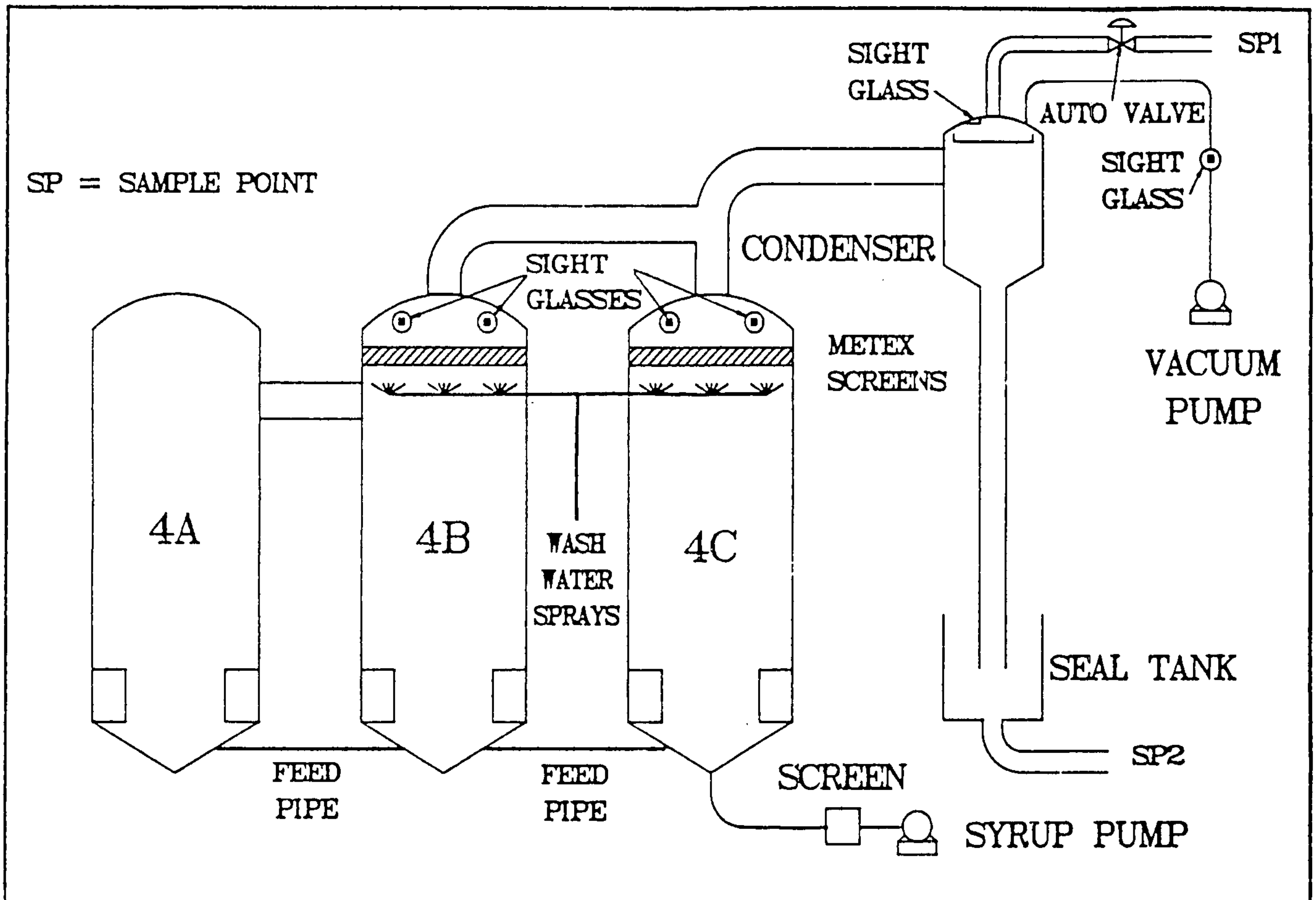

FIGURE 2 The general arrangement of the evaporator station last effect vessels.

ensure an optimum heat transfer coefficient. Visual checks to ensure adequate condensate removal were also carried out to optimise the heat transfer coefficient.

Faulty level control for the last effect could also contribute to carry-over and this aspect should be investigated. The level control valve could be faulty or manual control could be poor, causing fluctuating juice levels.

Blockages in the feed piping may also cause fluctuating juice levels. Fortunately no blockages were experienced although this aspect was considered. However, a broken feed pipe in the 4A vessel caused syrup to shoot up the tubes and overload the Metex screens in the 4B vessel, causing them to become partially choked. The screens lifted and syrup was by-passing to the evaporator condenser. This was seen through the sight glasses that had recently been fitted (Figure 2).

Pans

Sampling

Condenser water from individual pans was sampled as previously described. In addition, pans with external condensers were checked by taking a sample from the vapour pipe under vacuum using the 'bottle' method (Figure 3), and were taken also from the tailpipe. The samples were taken over a complete pan cycle.

For pans with internal condensers, a sample of condenser water out of the pan was taken over the duration of a complete pan cycle using the 'bottle' method.

When any of the above sugar traces exceeded the specified limits, causes were investigated and solutions found.

Entrainment return pipes

To prevent entrainment return pipes from becoming blocked, a 25 mm water pipe was connected at the top of the return pipe inside the pan save-all. This water pipe was opened at regular intervals by the pan boiler during a cycle to check whether the pipe was clear. All pan entrainment return pipes were fitted with sight glasses (Figure 3). A schedule on each weekend mill stop was instituted to ensure that rust build-up in the save-alls was cleared. Save-alls were also checked for holes, as short circuiting of the vapour path due to corroded save-alls may cause syrup/molasses to be carried straight into the vapour and tailpipe. This was observed in one of the pans. All pan vapour pipes were fitted with sample bottles, secured at a convenient point to the tailpipe (Figure 3). This is a convenient way to see at a glance any carry-over coming from any particular pan and is of benefit to the pan boiler.

Pan control

High boiling levels may also cause carry-over. All pan boiling levels should be calibrated, and safe working volumes should be demarcated with a red line. Violent circulation, especially when the pan is charging, should be prevented. Vacuum was controlled at a level lower than the working vacuum, and steam to the calandria was opened slowly when the pan was charging to prevent this occurrence. This was important with manual control but may not be as important if the pan is automatically controlled.

Vacuum leaks

Water surges in the pan sealwell would indicate a leak on the tailpipe. Should pan boilers observe a surge, the pan

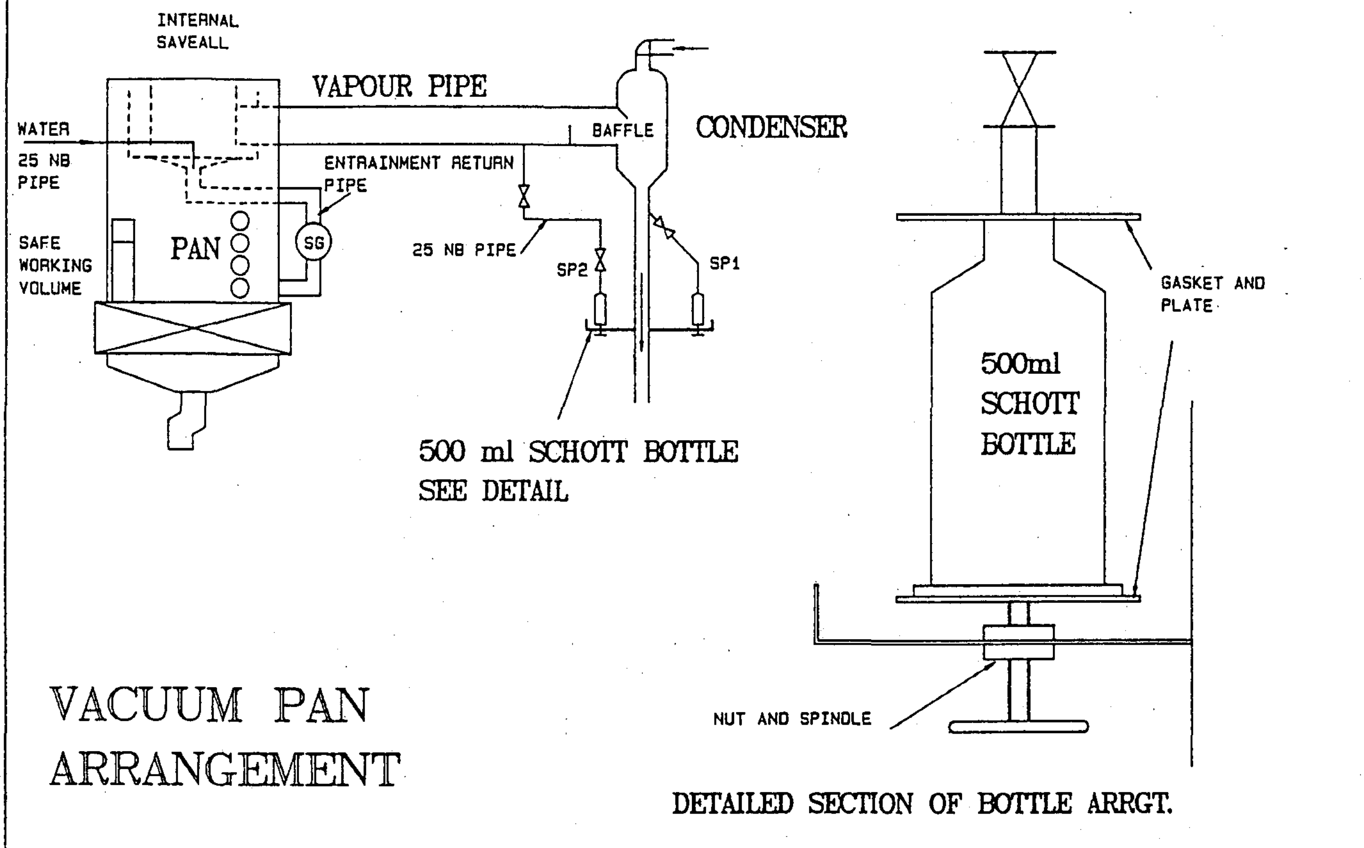

FIGURE 3 The "bottle" sample method installed on the pan vapour line.

should be pressurised with steam and the vapour piping, pan vessel and condenser should be checked for leaks.

Filter station

Sampling

The condenser water was sampled as previously described (Figure 4, S1).

In addition, a continuous sample under vacuum was taken on the return line to the filtrate receiver (Figure 4, S2) and analysed every two hours over a period of 24 hours to establish a trend. The quantity of sample collected in this case is important as a large quantity would indicate excessive carry-over.

If acceptable levels from the above two points are exceeded, an investigation should be made.

Filtrate pumps

Poor filtrate pump performance could be a serious cause of carry-over of juice to the condenser and cooling tower. To ensure this was not happening each filtrate receiving tank was fitted with a level gauge sight glass (Figure 4, LG1 and LG2). It could be seen at a glance if any of these tanks were remaining full and appropriate action could be taken. In addition, sight glasses were installed in the vacuum line just above the receiving tank going to the entrainment trap and were regularly inspected for carry-over (Figure 4, SG1). Sight glasses were also installed on the entrainment separator and on the return line to the receivers to enable a visual observation of the quantity of entrainment return (Figure 4, SG2 and SG3). This was conveniently installed in a position where the pan boiler had a clear view and action was taken if excessive entrainment return was observed.

A U-leg was installed on the return line to the high vacuum receiver to prevent by-passing of vacuum to the entrainment trap and also to act as a seal for juice returning to the receiving tank (Figure 4).

Vacuum leaks

The filter vacuum lines and condenser had to be checked for holes. A successful method was used whereby a valve was installed on the tailpipe of the condenser (Figure 4, V1). This valve was closed and water to the filter condenser opened so that the condenser was flooded. The flooded condenser overflowed into the vacuum lines, enabling the whole vacuum system to be checked for leaks. This method highlighted the poor state of the condenser (again relatively inaccessible) which has since been replaced in stainless steel.

Vacuum control

Loss of vacuum was caused by the operator scraping mud off the screens above the cut-off point, due to poor alignment of the scraper. Excessive leaks at the vacuum heads were also a source of erratic vacuum. The methods used to control vacuum head leaks have been previously described by Mack and Mackenzie (1987) and these were used by the maintenance department to prevent further leaks. In addition, all internal piping was checked for leaks by removing the vacuum heads and pressurising each pipe with water.

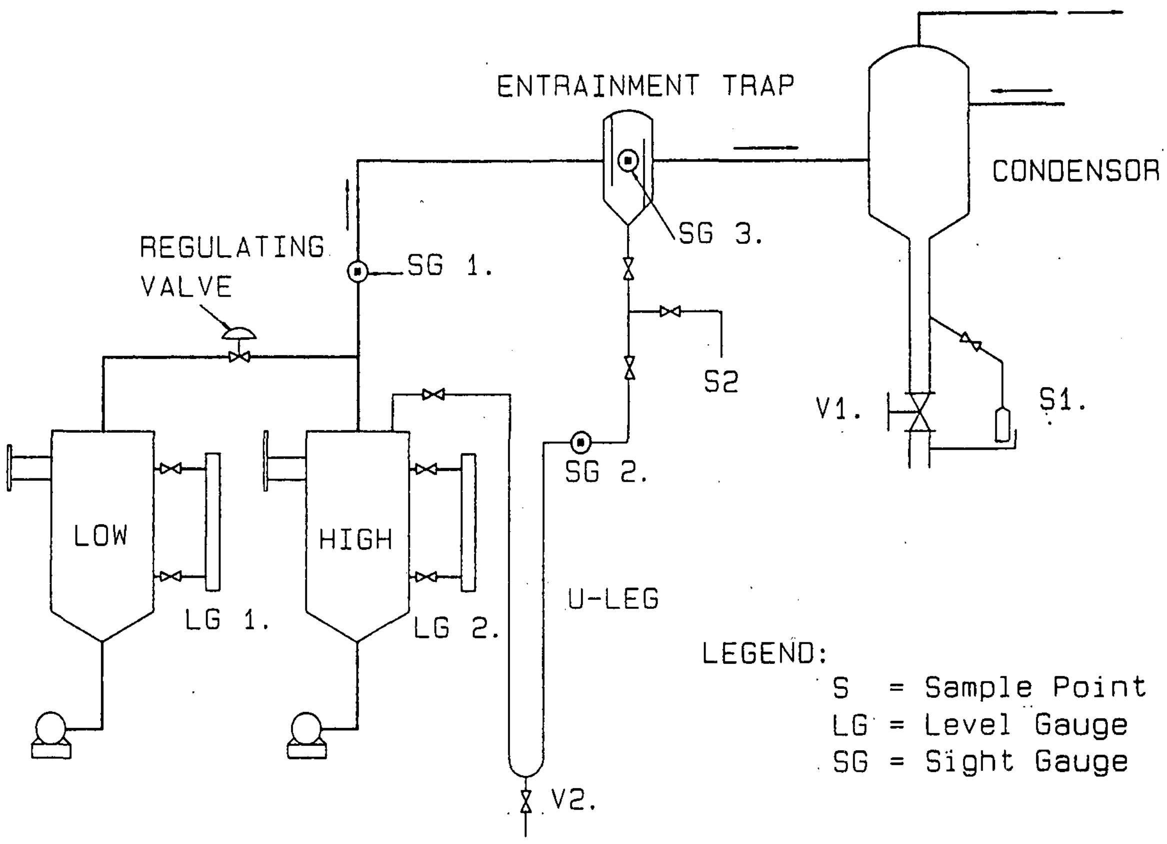

FIGURE 4 The general arrangement of the filter station, showing sample points and sight glass positions.

Other sugar loss sources

Crystalliser element leaks

Sugar losses to the cooling tower occurred through leaking cooling elements of the crystallisers, which are incorporated into the closed circuit system of the cooling tower.

Special care must be taken when sampling the crystallisers as the long retention time of water in the cooling elements of the crystalliser could lead to erroneous sampling.

For this sample, the following steps were taken:

The elements were flushed out with raw river water for one hour. Hot water was run through for half an hour to melt any massecuite that might have been in the cooling elements. Raw water was again flushed through for half an hour to remove all sugar traces before the first sample was taken. Once the crystalliser was well flushed out a catch sample could be taken. A sucrose figure greater than 20 ppm would indicate severe contamination. Catch samples were taken half-hourly to establish a trend.

Alternatively, the water could be allowed to stand in the cooling element for about 30 minutes before sampling. This would give the water time to dissolve any sugar that might have been leaking through.

Poor housekeeping

Sugar traces in the cooling tower may be caused by the washing out of catch trays into the closest seal well. The way to ensure this is not being done is by observation, and by counselling the personnel responsible for cleaning the trays.

Summary of findings

The 1990 season started off well for Umzimkulu and by week no. six, boiling house recoveries of above 92 (pol) were being achieved (Figure 1). No problems were observed until week no. 12 and, although an increase in sugar carry-over to the cooling tower was noted, undetermined pol losses remained at acceptable levels. However, at the 1 000 ppm level there was clearly a serious problem and the search for the contamination began in earnest.

Random sample checks were carried out at various points across the evaporators, pans and filter station but the results were inconclusive due to scatter. It also became apparent that visual observations were impossible due to the lack of sight glasses in strategic positions. Although many problems such as vapour leaks, choked pan entrainment returns, filter station pump problems, filter condenser leaks and crystalliser shaft leaks were identified, the problem remained. It was soon realised that a more systematic approach would have to be adopted and an intensive sampling programme was implemented in week 15.

Figure 5 shows the differences between sugar traces of the condenser water OUT from the evaporators, pans and filters, and those of the sample of condenser water IN taken at the same time. These tests were conducted over a period of four days and all showed similar trends to the 24 hour graph shown below. The graph was recorded on day 4 of week 15. Although there was a certain amount of scatter, the evaporator trend showed a greater increase of sucrose lost across the condenser than either the pans or filters. From the results obtained it was clear that the entrainment was occurring at

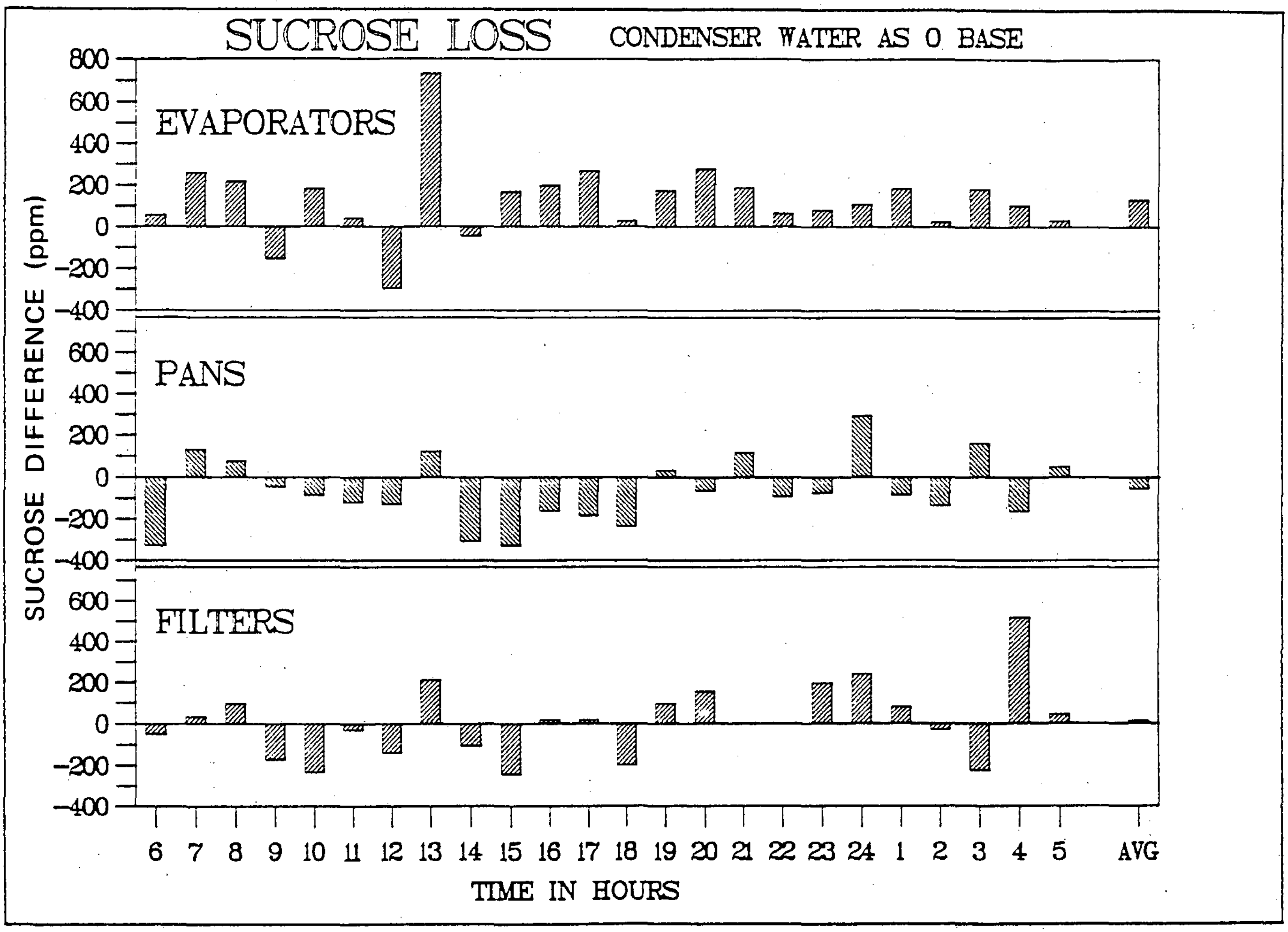

FIGURE 5 Magnitude of entrainment represented as the difference in sucrose in water IN and OUT.

the evaporators. This was the case as the Sunday stop revealed gaps in the Metex screens of the 4C vessel and partially choked Metex screens in the 4B vessel. These problems were rectified and after week 16 the sugar trace in the cooling tower reverted to normal (Figure 1).

A high carry-over was again evident in week 26, highlighted by laboratory analyses, and was visually detected after the first routine check. This was made possible by the new sight glasses installed in the 4B evaporator vessel. The symptoms observed were those described under 'Metex screens' of the evaporators. A set of special samples taken confirmed this and the problem was rectified during the weekend shutdown. From week 26 to the end of the year no further problems were experienced with carry-over to the cooling tower.

Sugar loss

To quantify accurately the sugar losses over a period of sugar contamination to a cooling tower is very difficult due to a number of factors affecting the degree of contamination, such as manual blowdown, the dilution effect from pans and evaporator condensers, and natural biodegradation of sugar in the tower.

A sucrose loss equivalent to 0,1% of factory throughput causing sugar concentrations in condenser water to increase by 20 ppm has been previously quoted by de Robillard and Purchase (1986). However, due to an unknown quantity of raw water being added to the cooling tower as blowdown during this period, meaningful figures using these calculations cannot be reached.

A further attempt using the known quantity of water circulation and the rise in ppm over a period of time was tried.

Figure 6 shows the carry-over trend based on a 24 hour average for each week in which high carry-over was recorded. It is evident that after the initial blowdown following each weekend stop there was a sharp increase in carry-over, but thereafter the continued manual blowdown clouds the issue, and the calculation, using the quantity of water recirculated as a basis, becomes erroneous.

A subsequent calculation based on the increase in undetermined loss in weeks 14 and 15 compared with the average undetermined loss for the season shows an estimated 112 tons of sugar could have been lost. As other factors beside carry-over could affect undetermined loss, this figure is merely an indication, but it is significant that in weeks 14 and 15 undetermined loss increased substantially.

Recommendations

It is important that correct sampling procedures and analyses be adhered to so that a trend may be established. Sample points must be installed so that sampling is done at the correct places.

The probable causes for each area where carry-over may occur, i.e. evaporators, pans, crystallisers and filters, must be systematically and comprehensively checked.

The following plant modifications were done and are suggested to facilitate investigations:

- Sight glasses on the evaporator condenser
- Sight glasses on the vacuum line from the evaporator condenser to the vacuum pumps
- Sight glasses above each set of Metex screens

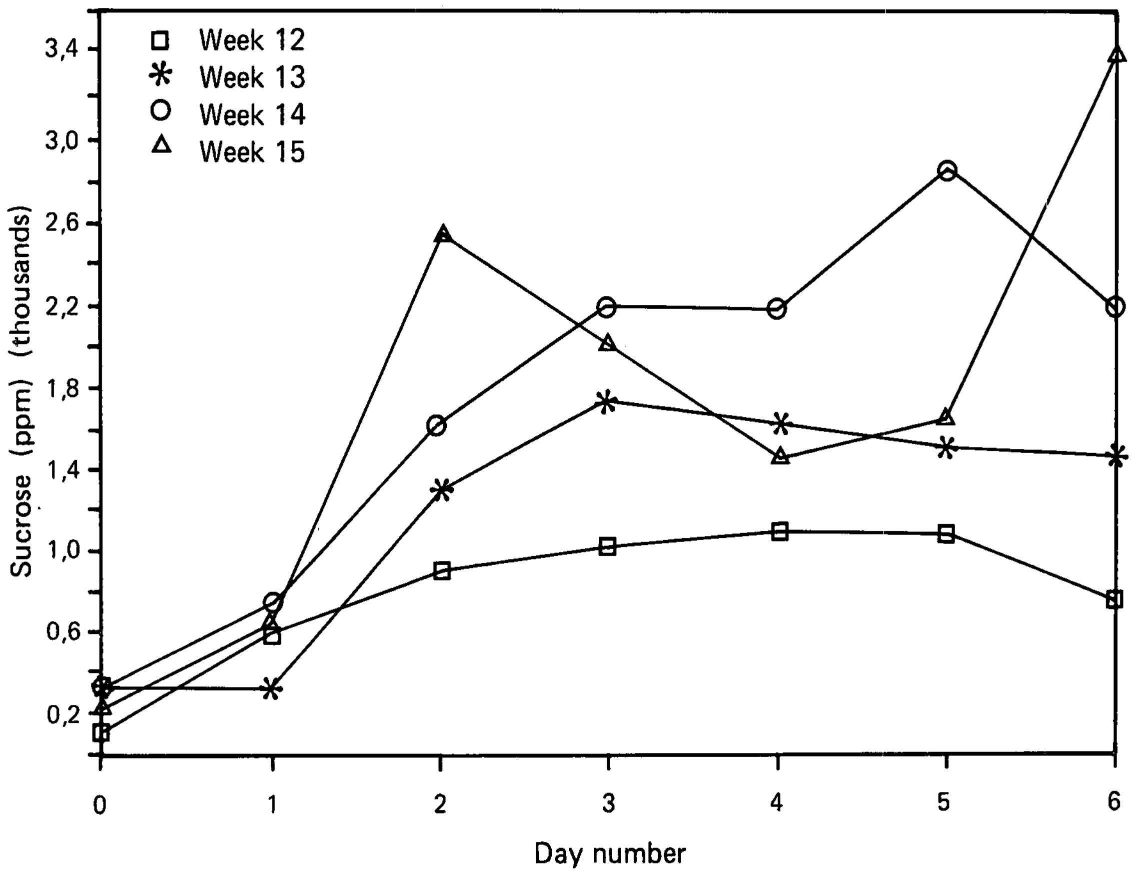

FIGURE 6 The sucrose loss in ppm recorded as a daily average for weeks 12 to 15.

- A recheck of the water sprays to clean the Metex screens on the run (Taylor, 1987). If necessary, implementation of a screen change roster
- Sight glasses on each pan save-all return pipe
- Installation of the 'bottle' sample system on all pans
- A wash system on all pan entrainment return pipes
- Sight glasses on the filter entrainment return line or catch pot
- Level gauge or sight glass on each filter vacuum receiving tank
- A U-tube arrangement on the filter entrainment return line.

Conclusions

Experience at Umzimkulu has shown that the implementation of a standard operating procedure for sugar losses to the cooling tower has resulted in less time spent finding and correctly diagnosing the source of contamination. It has also resulted in the process staff gaining confidence in looking for the carry-over problems.

The implementation of the modifications carried out to plant equipment has resulted in sugar losses to the cooling tower being maintained at below 30 ppm. The fact that further sugar losses have been prevented constitutes an additional financial saving.

The prevention of sucrose contamination to the cooling tower has resulted in a cleaner cooling tower and a cost saving in chemicals, improved heat transfer efficiencies and a reduction in metal corrosion in the plant.

From the experience at Umzimkulu it can with confidence be recommended that the implementation of these procedures and modifications will benefit performance in the factory.

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