PANFLOOR MODIFICATIONS THAT IMPROVED PERFORMANCE AT AMATIKULU MILL

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Abstract

The Amatikulu mill panfloor had areas which needed design improvements for efficient running of the factory. The pipes for venting heavy and light incondensable gases were separated in all the 85 m^3 batch pans to improve the rate of heat transfer. Changes made to the molasses feed ring in the main C-massecuite pan improved circulation and reduced massecuite temperatures, thereby reducing possible Maillard reactions. The condensate removal system in the vacuum pan was modified, and this resulted in reduced water hammer and improved pan circulation. The injection water exit troughs in the internal condensers of the B- and C-massecuite pans were extended to eliminate intermittent flooding of the pans. This paper reviews practical work done during the 2006-2007 off-crop which led to improved sucrose recoveries at the Amatikulu mill.

Keywords: factory process, panfloor, incondensable gases, condensate removal, feed rings, condensers, vacuum pans

Introduction

The Amatikulu mill was commissioned in 1965 and still has some of the original equipment installed at that time. The panfloor comprises three 85 m^3 batch pans for boiling A-massecuite, one 85 m^3 batch pan for B-massecuite and one 85m^3 batch pan for C-massecuite. There are also three 40 m^3 batch pans for preparing A, B and C seed. In the 2005-2006 off-crop it was found that some of the process equipment had design shortfalls that needed improvement to achieve higher sucrose recoveries. The vent pipes for heavy and light incondensable gases in the 85 m^3 A, B and C batch pans were joined. The 85 m^3 C-massecuite batch pan had a feed ring positioned close to the downtake, and this adversely affected the massecuite circulation pattern. The vacuum pans condensate collection tank was undersized and the piping configuration adversely affected condensate withdrawal, resulting in water hammer and reduced heat transfer in the pans. The open areas of the injection water exit troughs in the 85 m^3 B and C batch pans were too small and this resulted in injection water flooding back into the pan when water demand was high.

Incondensable gas vent pipes

Factory process steam and vapour contains air and incondensable gases. If these gases are not removed, they accumulate inside the calandria and reduce the rate of heat transfer. For effective heat transfer to take place the incondensable gases are removed through pipes which vent into the atmosphere. The pipes are normally separated between heavy and light incondensable gases. The pipe for the light gases is traditionally located at the top periphery of the downtake in the form of a ring with holes for gas extraction. For heavy incondensable gases, a ring pipe is located at the bottom periphery of the downtake. In such an arrangement both light and heavy incondensable gases are effectively removed from the calandria.

At Amatikulu mill the ring pipes for light and heavy incondensable gases were found to be joined on the inside of the calandria as well as on the outside of the pan (Figure 1). This led to preferential withdrawal of the light gases, and resulted in reduced heat transfer area and poor massecuite circulation in the vacuum pan.

During the 2006-2007 offcrop, the vent pipes for the light and heavy incondensable gases were separated both on the inside of the calandria and on the outside of the pan (Figure 2).

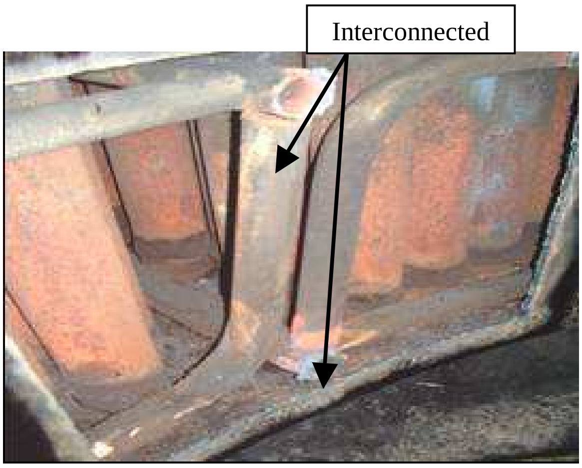

Figure 1. Pipes for light and heavy incondensable gases interconnected inside calandria.

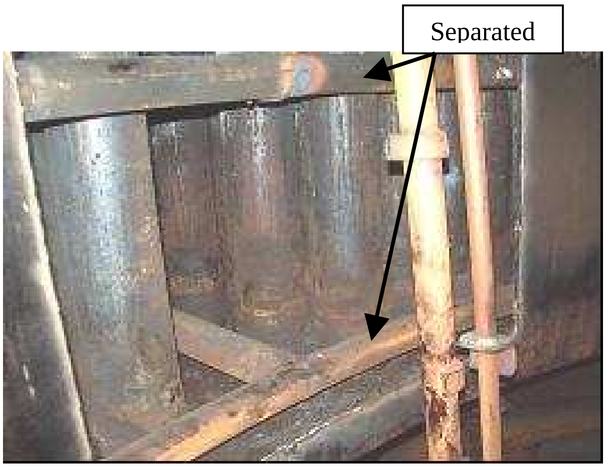

Figure 2. Pipes for light and heavy incondensable gases separated.

Pan 5 feed ring

Circulation plays a very important role in crystallisation rate, massecuite temperature, uniform crystal growth and exhaustions (Hulett, 1965). The pan design must therefore promote good circulation and eliminate ‘dead zones’ to encourage uniform crystal growth (Hulett, 1965). The pan feed, which is normally treated in a ‘blow up’ tank, has a temperature that is slightly higher than the temperature of saturated vapour pressure in the pan. As a result, when the feed enters the pan, it will flash. The flashing is desirable, since it improves massecuite circulation. However, the feed point of the molasses is critical, especially for C-massecuites, because they are viscous. Since vapour bubbles from the feed flash move upwards, it is important that the feed point is correctly situated where natural circulation in the pan will be encouraged. This would be the point where the massecuite flow is directed upwards through the calandria tubes, and preferably towards the periphery of the pan.

At Amatikulu it was found that the feed ring was close to the downtake. This arrangement promoted preferential flashing up the downtake, against the natural flow of massecuite, thus distorting the flow pattern in the pan. The feed ring in Pan 5 was subsequently moved towards the periphery of the pan so that flashing would occur below the tubes and towards the pan periphery (Figure 3).

Good massecuite circulation is achieved when the distribution of the feed from the feed ring is even. An uneven feed distribution will result in uneven and poor massecuite circulation in the pan. The feed hole size and the number of holes in the Pan 5 feed ring were checked, and it was found that the number of holes in the feed ring was twice that required. This was rectified by blanking off every alternate hole to achieve the required number and ensure even distribution of the feed.

The even feed distribution and correct positioning of the feed ring resulted in better massecuite circulation in the pan, more regular grain size and improved molasses exhaustion.

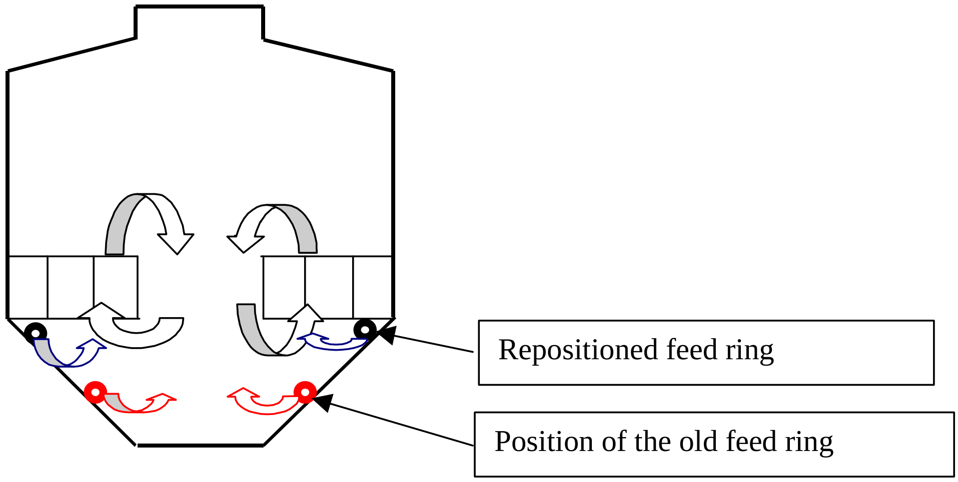

Figure 3. Representation of circulation pattern inside Pan 5 at Amatikulu mill, showing repositioned feed ring.

Injection water troughs

An automated valve in the injection water line controls the absolute pressure in a vacuum pan. It opens and closes depending on the pan absolute pressure. If for any reason water is restricted to the condenser this may lead to high absolute pressures and high massecuite temperatures, which will increase the chances of a Maillard reaction occurring. A Maillard reaction in turn will increase the viscosity of the massecuite, destroy some sucrose and have an adverse effect on crystallisation rate (Newell, 1979).

At times the B-massecuite pan at Amatikulu experienced flooding. This occurred whenever the condenser demanded more water than it could discharge. The excess water diluted the massecuite and caused an increase in boiling times. It was thought that the mouth of the outlet was too small to allow the injection water to exit the trough without creating turbulence. Poor removal from the internal condenser would cause the accumulated injection water to overflow back into the pan. This was confirmed by doing trials after factory shutdown. It was found that the injection water valves could be opened only up to a point, beyond which water would flood back into the inside of the pan. This problem was overcome by extending the length of the injection water trough from 500 to 1280 mm, which more than doubled the area of the outlet trough and made it easier for the water to flow out of the condenser (Figures 4 and 5).

Figure 4. Unmodified injection water trough.

Figure 5. Extended feed water trough.

Pan condensate tank

For maintenance purposes, a section of the Pan 1 steam chest was cut away during the 2005-2006 off-crop to expose the section of tubes located at the condensate outlet (see Figures 6 and 7). The stainless steel calandria tubes were fouled by various degrees of scale, and the inspection clearly showed an interface line that defined the level of condensate in the calandria. The interface line at the condensate outlet was ±50 mm from the bottom of the tubes, while the interface line on the tubes furthest away from the condensate outlet was ±100-120 mm. This was clear evidence that poor drainage was causing a build-up of condensate in the calandria, and was subsequently leading to poor heat transfer and longer boiling times.

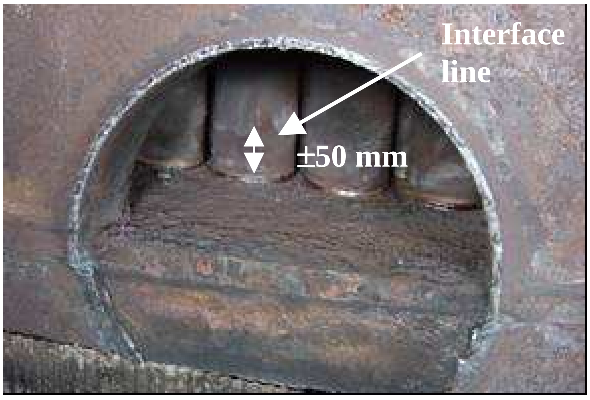

Figure 6. Condensate level of ±50 mm at condensate outlet.

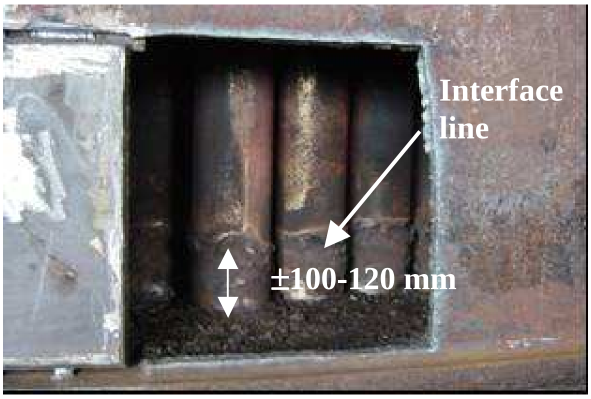

Figure 7. Condensate level of ±100-120 mm and soft scale on calandria tube plate.

The A pans were observed while in operation during the crushing season and the following problems were noted:

- When boiling the A pans, condensate spouted continuously from the vent pipe, indicating that the heavy incondensable pipe was submerged in condensate. The heavy incondensable gases accumulating inside the pan calandria were reducing the heat transfer coefficients and causing longer boiling times.
- The flash tank was found to be undersized for the amount of condensate coming from all eight pans. This caused condensate to build up in the flash tank and cascade back into the steam chest of the pans. The flash tank had been fitted with a sight glass on the flash line for checking purposes, and intermittent condensate entrainment could be seen here, especially when all the pans were boiling massecuites.

It was also established that the manifold that received all the condensate prior to the condensate tank was undersized and that flashing was taking place in this manifold. The end result was a restriction of condensate flow in the manifold due to the presence of the flash, and this further exacerbated the poor removal of condensate from the pan calandrias.

A bigger flash tank with correct pipe sizes was installed to allow for easy condensate drainage to improve pan performance and throughput. It was decided to remove the manifold and direct the individual condensate pipes from each pan into the larger condensate receiver, to eliminate any restriction of flow due to flashing in the manifold.

Benefits after the modifications

The following benefits were realised:

- *Improved circulation in the pans*, which was verified by the panboilers on the floor. Confirmation of the improvement was obtained when it was found that all of the A pans could now be used for the preparation of A seed from B magma. Prior to the modifications only one pan, which had previously been modified to facilitate removal of heavy incondensable gases, could be used to boil A seed. This pan had been used almost exclusively for preparing A seed because the evaporation rate and circulation had been considerably better in this pan than in the other unmodified pans. After the modifications to the incondensable gas pipes and the installation of the new condensate tank, all three A pans could be used for A seed preparation.
- *Increased pan capacity*. Good circulation results in improved crystallisation rates. This is now evident in the number of A-massecuite strikes that can be boiled per day during the peak sucrose period. Figure 8 shows a comparison of the number of pans discharged per day during the months of August and September in 2002 and in 2007 (2002 was chosen for the comparison as it was a bumper crop year). After the modifications, a maximum of 18 strikes/80 m^3 batch pan/day was achieved five times in 2007, compared to 2002 where 17 strikes per day was the maximum that could be achieved. The strike rate decreased towards the end of 2007 due to poor cane supply and lower time efficiencies.

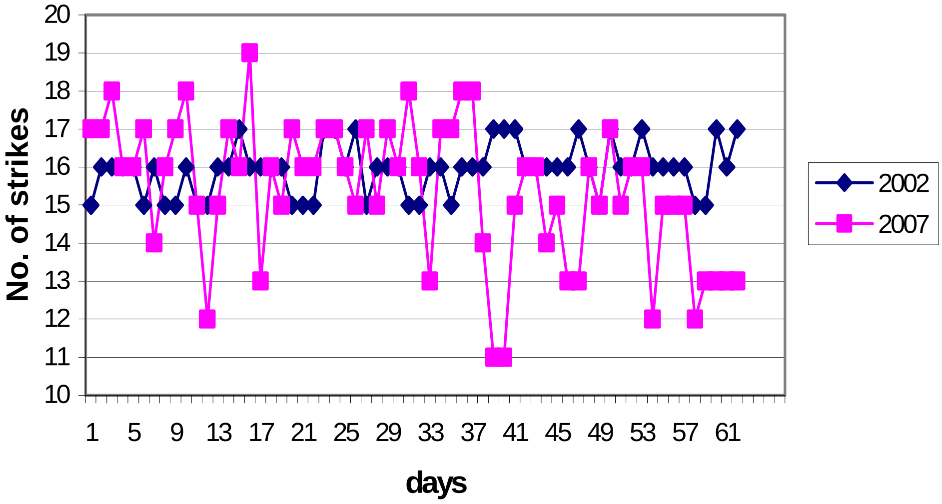

Figure 8. Comparison of maximum strikes achieved per day in August and September 2002 and for the same period in 2007 at Amatikulu mill.

- *Lower boiling temperatures in the C-massecuite pan*. Prior to 2006 high massecuite temperatures were a problem, especially during summer, when the injection water temperatures would often reach 36ºC and initiate Maillard-type reactions in the C-massecuite. Repositioning of the feed ring and separation of the pipe vents for heavy and light incondensable gases resulted in a lower average massecuite temperature of 64ºC, as opposed to an average of 67ºC before the modifications.
- *Improved TPD*. Improved pan circulation contributed to improved molasses exhaustion. Ninela and Rajoo (2006) highlighted improved Target Purity Difference (TPD) figures as a result of boiling at lower temperatures in 2005. A further improvement in TPD was achieved in 2007 (Figure 9). At the time of reporting, the 2007 figure was 3.6, whereas in 2005 it was 4.5.

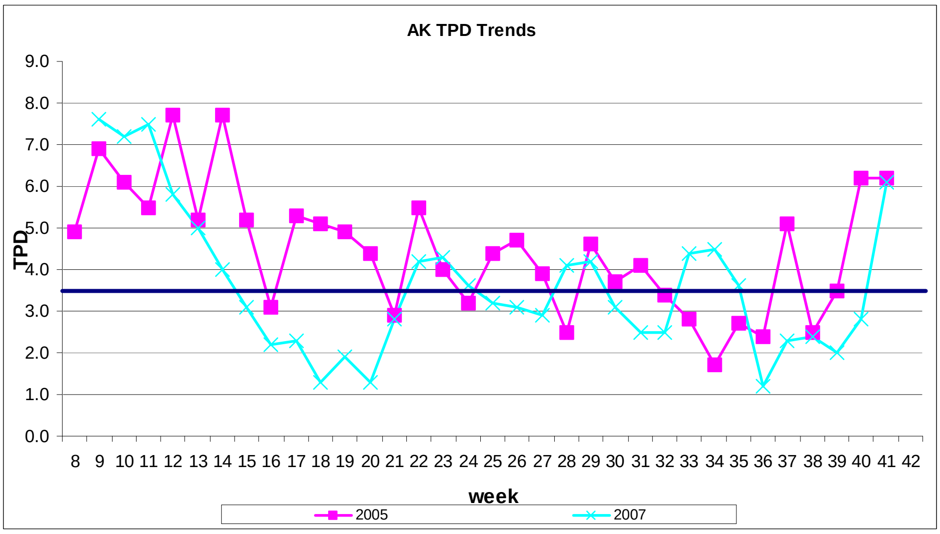

Figure 9. Comparison of target purity difference (TPD) trends at Amatikulu mill in 2005 and 2007.

- *Improved CRB*. Corrected Reduced Boiling House Recovery (CRB) essentially determines how efficiently sugar is recovered and molasses is exhausted. It is independent of juice quality and reflects only those factors that are within the control of factory process management (Lionnet and Koster, 1987). The improvement in CRB since 2006, with a record 88% in 2007, is an indication of the improved molasses exhaustion achieved in 2006 and 2007 as a result of modifications to the incondensable gas pipes and the pan feed system, and of enhanced condensate removal in the C-massecuite pan (Figure 10).

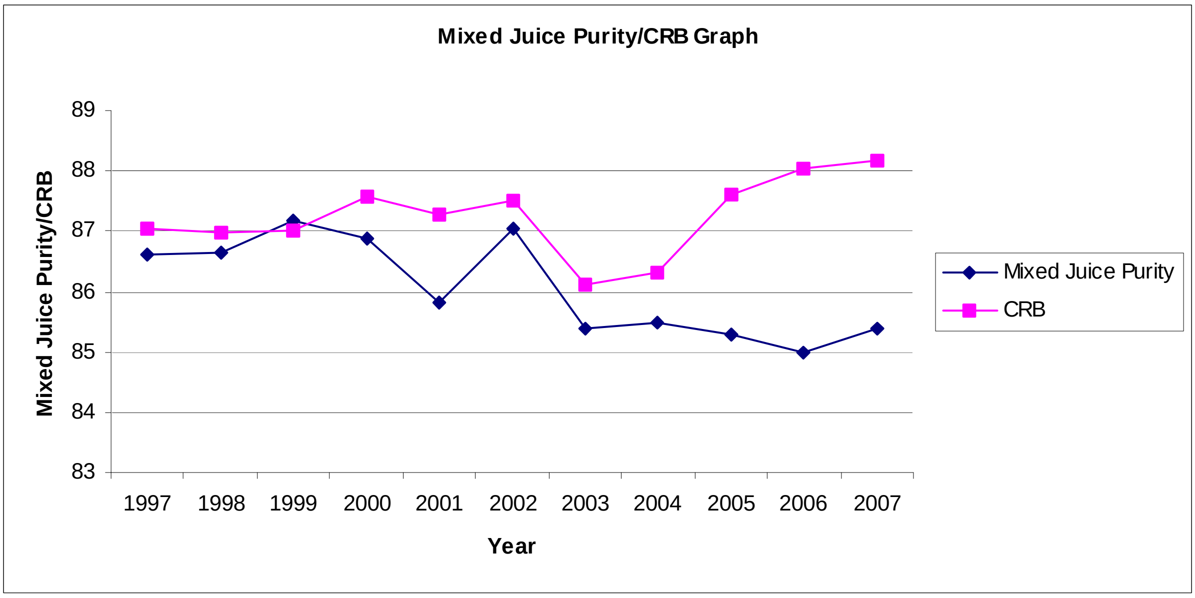

Figure 10. Mixed juice purity and corrected reduced boiling house recovery (CRB) at Amatikulu from 1997 to 2007.

Conclusion

All the modifications reported here were completed during the 2006-2007 season off-crop, and have together led to improved sucrose recoveries. It is without doubt that CRB achieved new levels above 88% since 2006. However, no individual modification can be singled out as the main contributor to increased production at the Amatikulu mill, but rather a combination of the modifications.

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REFERENCES

Lionnet GRE and Koster KC (1987). A boiling house recovery formula independent of juice quality. *Proc S Afr Sug Technol Ass* 61: 30-32.

Newell GM (1979). A preliminary investigation into factors affecting gas formation in massecuite and molasses. *Proc S Afr Sug Technol Ass* 53: 62-65.

Hulett D (1965). Where should the downtake be? *Proc S Afr Sug Technol Ass* 39: 30-33.

Rouillard EEA (1985). Massecuite boiling. *Proc S Afr Sug Technol Ass* 59: 43-47.

Ninela M and Rajoo N (2006). Practical steps taken at Tongaat-Hulett sugar factories to achieve low target purity differences. *Proc S Afr Sug Technol Ass* 80: 448-461.